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ROHM & HAAS COMPANY

REDSTONE ARSENAL RESEARCH DIVISION
HUNTSVILLE, ALABAMA

Report No. S-81

ABLATION OF EXTREME-TEMPERATURE-RESISTING MATERIALS IN ROCKET EXHAUSTS

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ROHM & HAAS COMPANY

REDSTONE ARSENAL RESEARCH DIVISION
HUNTSVILLE, ALABAMA

ABLATION OF EXTREME-TEMPERATURE-RESISTING MATERIALS IN ROCKET EXHAUSTS

ABSTRACT

The ablation rate of contoured Micarta®[1] specimens immersed in solid propellant exhaust gases has been measured under closely controlled conditions. The effect of particles in the exhaust stream was demonstrated by carrying out firings with propellants containing 0.5%, 8%, and 16% aluminum. Firings at chamber pressures of 400 psia and 550 psia showed the effect of pressure on ablation rate. The ablation rate increased directly with chamber pressure and aluminum content of the propellant.

Raw data for heating rate calculations were obtained for each propellant from instrumented copper calorimeters and heat flux transducers.

[1] Trademark for a group of laminated plastics, Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania.

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1. INTRODUCTION

It is known that the presence of particles in the exhaust gases of solid propellant rocket motors has a great effect on the ablation rate of protective materials exposed to these gases. There are, however, little quantitative data available which would facilitate selection of the most suitable materials for blast deflectors, jet vanes, and other hot missile parts.

Under the direction of the Structures and Mechanics Laboratory of the U. S. Army Missile Command, the erosion rates of ablative specimens immersed in solid propellant gases were determined under carefully controlled conditions. In addition temperature versus time measurements from instrumented copper calorimeters were made at identical firing conditions to provide data for the calculation of heating rates. This report describes the propellant formulation work, the calorimeter and specimen tests, and summarizes the data.

This is the final technical report for Contract DA-01-021 AMC-11660(Z) under which this work was funded.

2. TEST PLAN

The test plan called for static testing of solid propellant motors with calorimeters and ablative specimens immersed in the exhaust stream. Ablative materials and instrumented calorimeters were to be provided by the Structures and Mechanics Laboratory.

Propellants were to be formulated with at least three variations in aluminum content and flame temperatures greater than 4000°R (2222°K). The motors were to have a nozzle exit diameter of three inches and mass flow rate at the nozzle exit of 0.5 lbm/in^2-sec. The nozzle exit pressure was to be approximately equal to the ambient pressure.

The temperatures indicated by ten 30 gage chromel-alumel thermocouples in the calorimeters were to be recorded by a rapid-response oscillograph and suitable calibration factors provided. The thickness of material removed from the ablative specimens in the test, the motor chamber pressure, and the burning time were to be recorded and reported. The behavior of each specimen during firing was to be recorded in a high-speed color movie and before and after conditions documented with still photographs.

The original test plan specified a motor firing time of 5 seconds to provide reliable heating rate data from the calorimeters and measurable material loss from the composite specimens during exposure to the exhaust gases. In the course of motor development and propellant formulation work it was found that a copper calorimeter was quickly melted at these firing conditions and that marginal heating rate data would be obtained.

On the basis of other exploratory firings the test plan was modified. Ablation tests would be carried out with three low-flame-temperature propellants with 0.5%, 8.0%, and 16.0% aluminum contents. The three propellants were to have approximately the same flame temperature at 550 psia chamber pressures, and the motors were to be fired at 400 and 550 psia. Further, a heat flux transducer was to be used in place of one of the thermocouples during the calorimeter tests and during 3 of the ablation tests. The firing duration was to be about 2 seconds for the propellants containing 8.0% and 16.0% aluminum and about 3 seconds for the propellant with a 0.5% aluminum content.

3. DESCRIPTION OF ABLATIVE SPECIMENS AND CALORIMETERS

3.1 Ablative Specimen

The ablative specimens had a "nose cone" appearance with a 1.25-inch spherical radius at the stagnation point and a 2.12-inch length (Fig. 1). The specimens were made from Micarta 259-2, a laminated glass-phenolic material, and the laminations were oriented parallel with the centerline of the specimen. The weight of each test specimen was about 0.6 lb.

3.2 Copper Calorimeter

The calorimeters were fabricated from electrolytic-tough-pitch copper and had the same size and shape as the ablative specimens (Fig. 2). Thirty gage chromel-alumel wire was mechanically joined to form a thermocouple in each 0.024-inch diameter hole by inserting the ends of the wire into the hole and peening the sides of the hole together. The thermocouples were numbered 1 thru 10 and the depth of the thermocouple was the distance along the side of the plug from the leading edge to the centerline of the hole. The depth of each thermocouple is given in Table A1 (Appendix A).

3.3 Specimen Holder

The calorimeters and ablative specimens were supported in the exhaust stream by a 1" diameter pipe and an adjustable fixture attached to the support block (Fig. 3). Four $\frac{1}{4}$-inch cap screws held the specimens on a steel flange welded to the pipe. The thermocouple wires were threaded through the pipe to protect them against the motor exhaust.

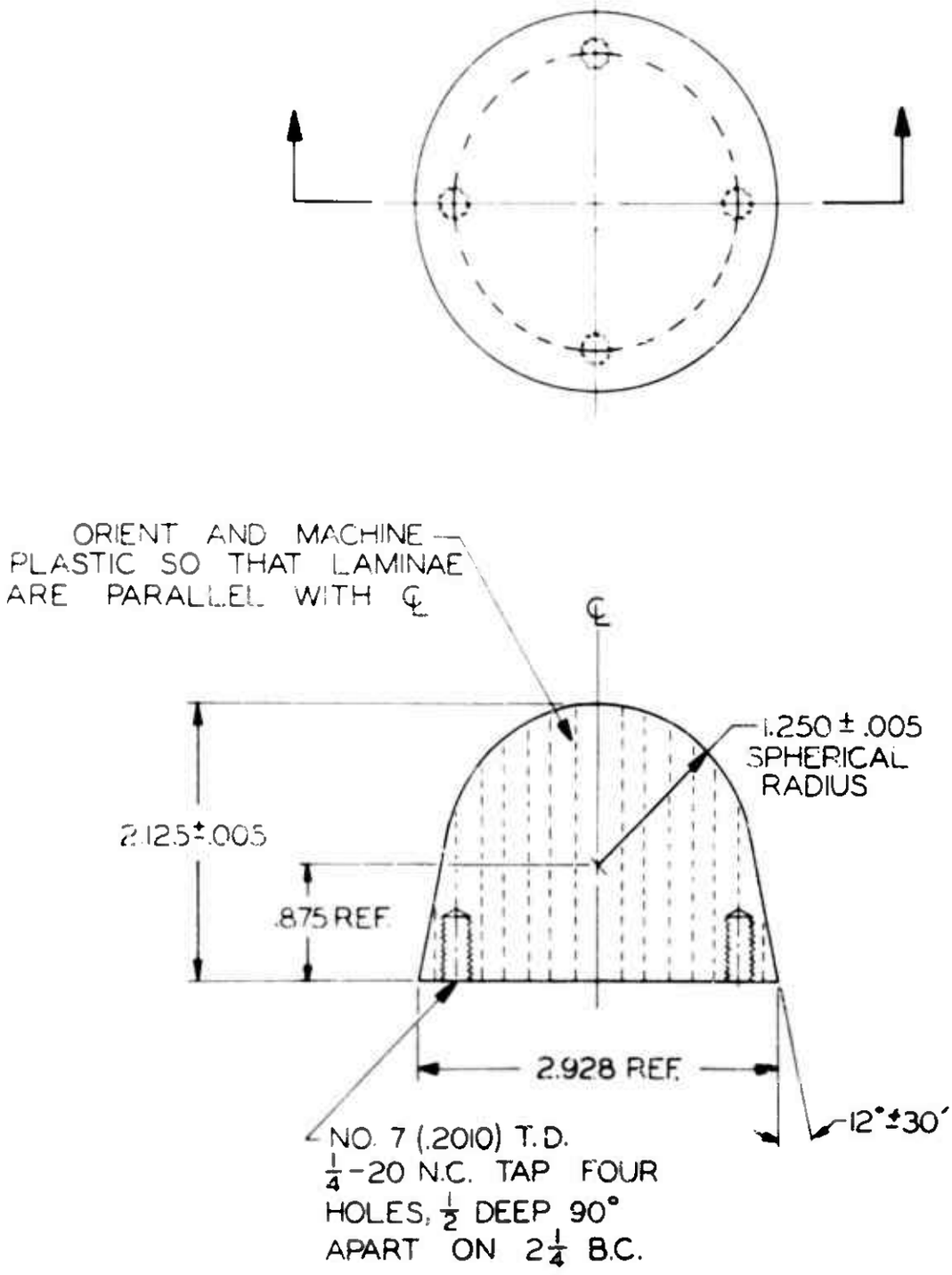

FIG. 1 CONTOUR OF ABLATIVE SPECIMENS

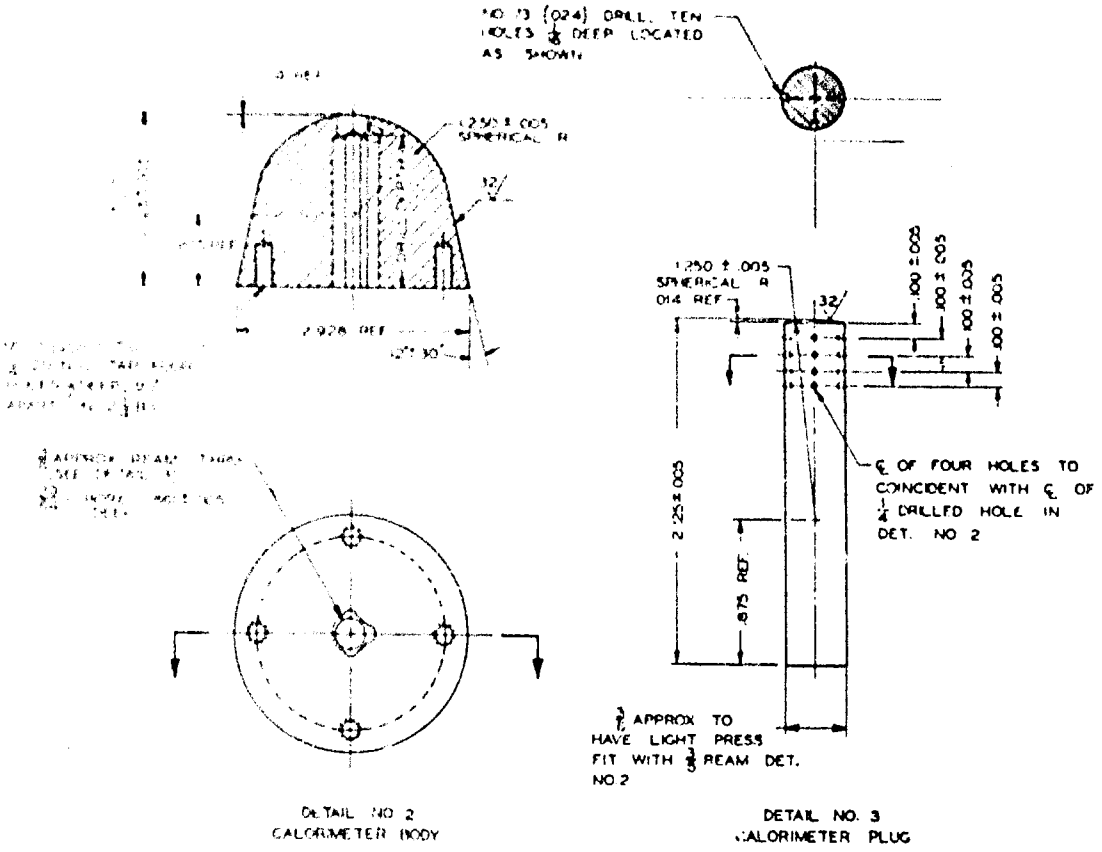

FIG. 2 DETAILS OF COPPER CALORIMETER

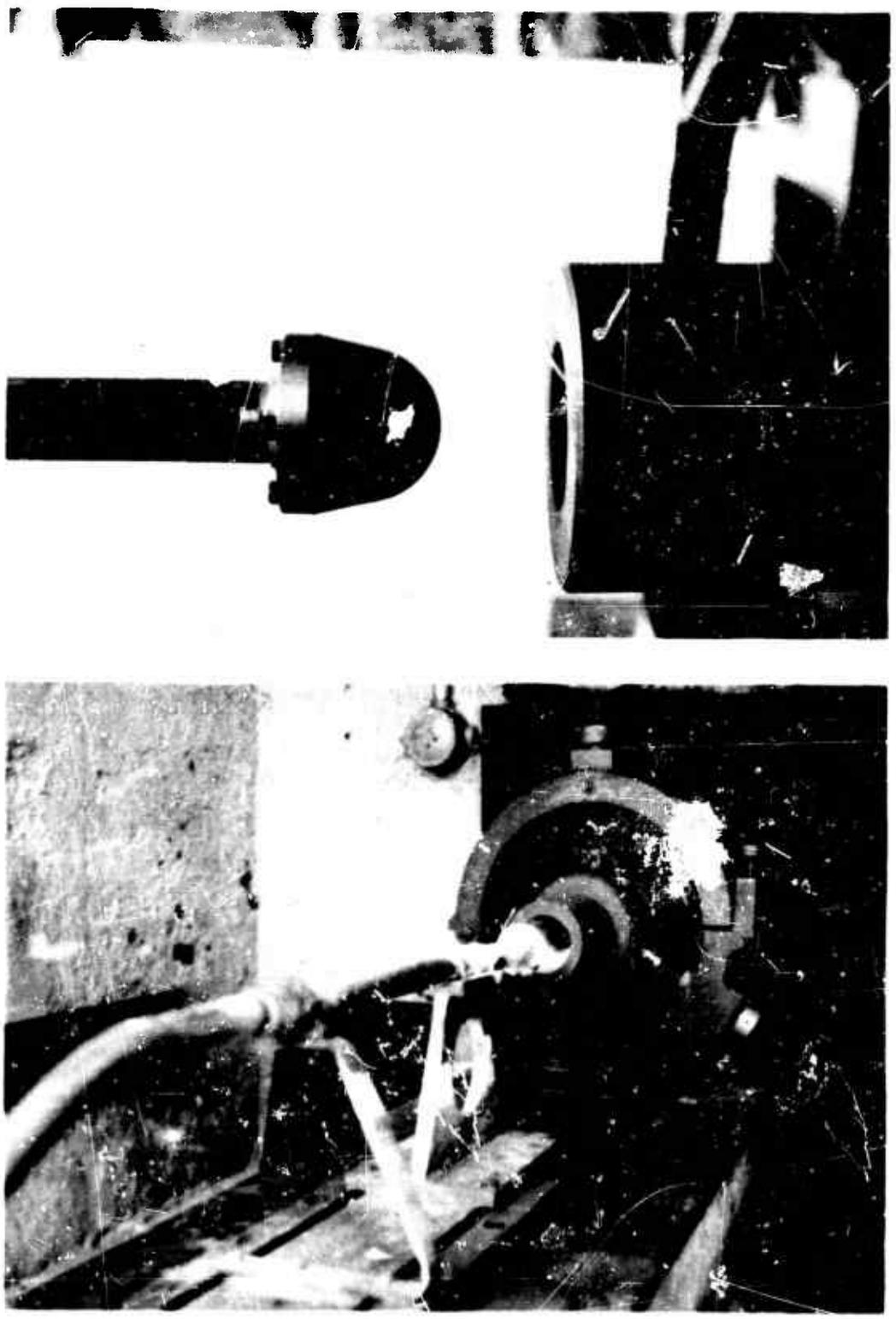

FIG. 3 SPECIMEN HOLDER AND SUPPORT FIXTURE

4. PRELIMINARY PROPELLANT DEVELOPMENT AND TESTING

A significant amount of propellant development and testing was carried out to achieve the originally specified firing conditions. This section summarizes the work and discusses the reasons that a change was found necessary.

4.1 Propellant Formulation for a Slotted-Tube Grain

The testing conditions were found to require propellant grains having a minimum mass of 18 lbm. Motor hardware and casting fixtures were available for a slotted-tube grain weighing about 30 lbs. A large number of these grains had been fired and the neutral pressure trace and uniform mass discharge rate were ideal for the purposes of this program. However, there were two drawbacks:

a. This design has a 1.5-inch web so that the propellant burning rate would have to be about 0.3 in/sec to achieve the 5-second burning time. This would require some propellant development.

b. The effect of the five 3-inch slots on the gas flow patterns was unknown. It is well-known that grains having slotted or star-shaped ports channel the flow and oxide particles such that non-uniform erosion and heat transfer occur on the nozzle's converging face and in the throat. This would be undesirable in this test.

Twenty 2C1.5-4[1] motors were fired to characterize three slow-burning-rate propellants for use in the slotted-tube motor. The firings, which were at relatively low pressures, had a considerable build-up of slag in the nozzle and motor case. In another program several slotted-tube motors containing a high-flame-temperature propellant with 18% aluminum were fired with the slots at the head of the motor; the pattern of the slots was visible in the slag deposited in the convergent portion of the nozzle but not in the throat. It was decided that a high-flame-temperature propellant should be used in an end-burning configuration to minimize oxide build-up and to insure uniform gas flow.

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[1] This nomenclature identifies a cylindrical port grain with a 2-inch O.D., 1.5-inch I.D., and 4-inch length.

4.2 Propellant Formulation for an End-Burning Charge

Plastisol nitrocellulose composite propellants have a high flame temperature and have excellent processing characteristics over a wide range of aluminum content. Compositions RH-P-399, RH-P-400, and RH-P-401 were formulated with 16.0%, 0.5%, and 8.0% aluminum, respectively. The properties of these propellants are given in Table I; the burning rates at 1000 psia chamber pressure were about 0.7 in/sec.

Table I

Theoretical Thermochemical Properties of Propellants

	RH-P-399	RH-P-400	RH-P-401
Aluminum Content, %	16	0.5	8
Chamber Pressure, psia	1000	1000	1000
Exhaust Pressure, psia	14.7	14.7	14.7
Chamber Temperature, °K	3413	2922	3166
Exhaust Temp. (frozen), °K	1700	1330	1510
Exhaust Temp. (equil.), °K	2033	1420	1695
Exhaust Enthalpy (frozen), Kcal/100 grams	-126	-129	-128
Exhaust Enthalpy (equil.), Kcal/100 grams	-130	-131	-131
Exhaust Specific Heat Ratio	1.20	1.24	1.22
Principle Components of Exhaust, moles/100 grams			
CO	1.230	0.621	0.968
CO_2	0.124	0.733	0.386
N_2	0.353	0.418	0.386
H_2	1.076	0.497	0.725
H_2O	0.483	1.261	0.937
HCl	0.238	0.366	0.305
Al_2O_3 (solid)	0.296	0.009	0.148

The end-burning charge configuration was selected as the best way of obtaining a neutral pressure trace and a uniform gas flow pattern in a compact motor case. A 14-inch diameter grain was designed to take advantage of the existing 14.5-inch diameter hardware. The mass discharge rate of about 0.77 lbm/in^2-sec at the nozzle exit was a little higher than necessary, but acceptable.

Propellant shrinkage during the curing process can cause case bond failures and cracks in a solid propellant grain cast directly into the motor case. To avoid this problem it was decided to cast the propellant into a 14-inch diameter cup molded from liner material. During curing the flexible cup would permit the grain to shrink without building up any internal stresses. The plastic cup containing the propellant would be slipped into the motor case and held in place during firing with grease or a mastic compound. The liner material would restrict the sides of the grain so that burning would occur on the face only.

4.3 Results of Preliminary Testing

4.3.1 Exploratory Firings with High-Flame-Temperature Propellants

While design and fabrication of the cup molding and grain casting fixtures were being done, eighteen 2C1.5-4 motors were fired to obtain P-K-r data for the propellant (Fig. 4), and six nozzles were sized and made for the 14.5-inch motor. Also, one firing was made with a calorimeter to check out the computer program for reducing the thermocouple data in digital form. Two other firings were made to obtain an estimate of the ablation rate of the plastic specimens.

A copper calorimeter with four thermocouples was placed two inches from the nozzle exit of a 6C3-11.4 motor containing 16% aluminum propellant (RH-P-399). The motor operated at 706 psia with a mass flow rate at the nozzle exit of 0.50 lbm/in^2-sec (Table II). The computer program performed satisfactorily even though the surface of the calorimeter began melting in less than 230 msec (Fig. 5).

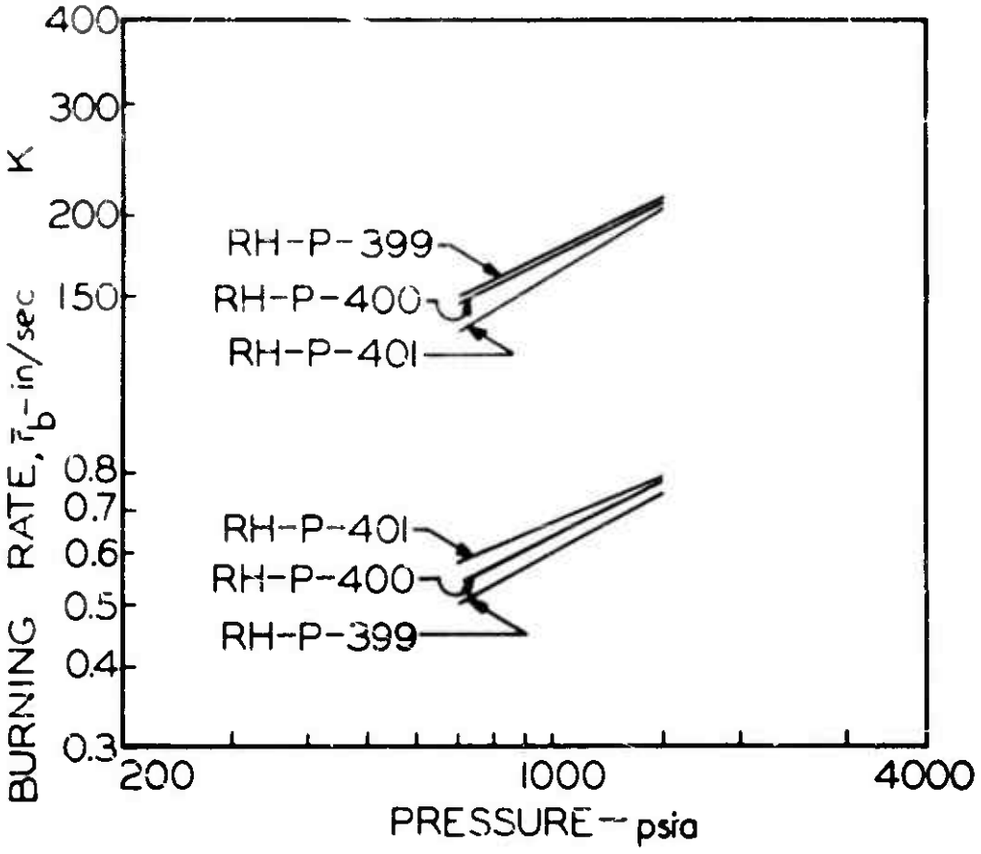

FIG. 4 PRESSURE-K-BURNING RATE RELATIONSHIPS FOR HIGH-FLAME-TEMPERATURE PROPELLANTS

Table II

Results of Exploratory Firings With High Flame Temperature Propellants

Grain Number	Propellant	Aluminum Content %	Average Motor Pressure (psia)	Grain Mass Flow Rate (lbm/in² sec)	Action Time (sec)	Expansion Ratio	Theoretical Exit Mach Number	Test Specimen Material	Length Before Firing (in)	Length After Firing (in)	Ablation Rate (in/sec)
6960	RH-P-399	16	790	0.50	1.000	6.00	5.19	Copper	--	--	*0.56
6966	RH-P-399	16	731	0.50	1.000	6.01	5.17	Silicone 599-2	2.116	1.100	0.355 *
6961	RH-P-401	16	714	0.46	1.760	10.17	6.29	Silicone 599-2	2.116	1.976	0.045

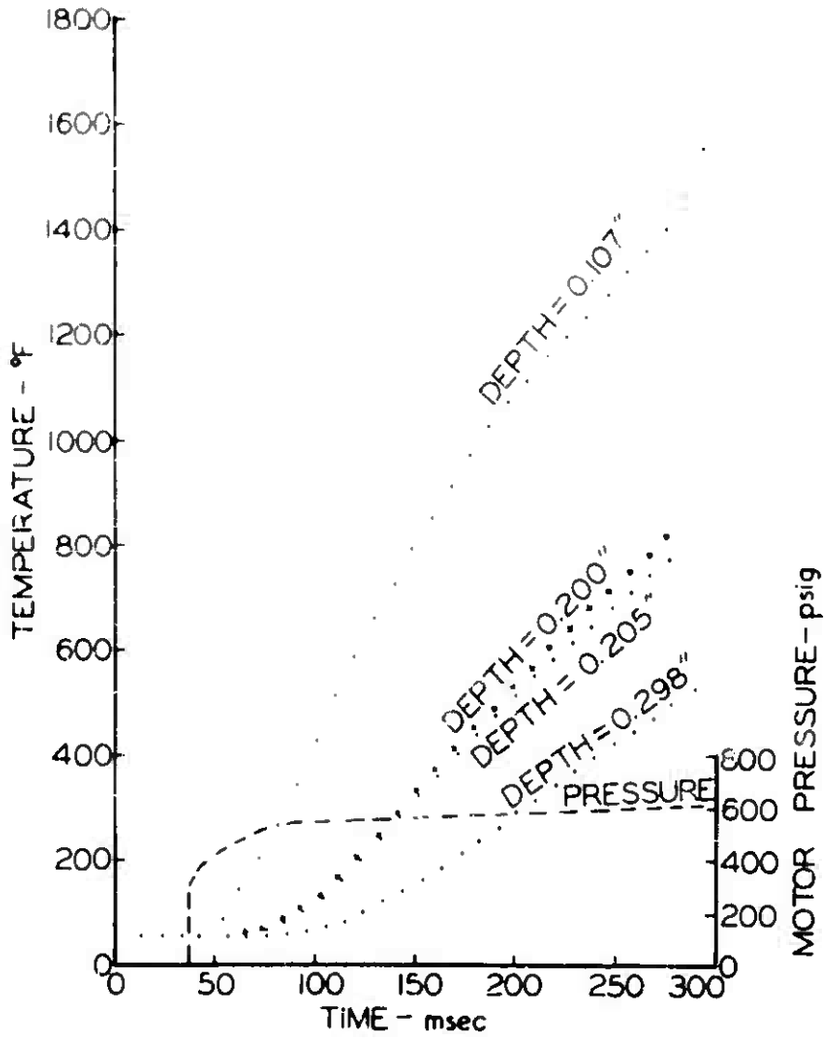

FIG. 5 MOTOR PRESSURE AND CALORIMETER RESPONSE FOR A FIRING WITH 16% ALUMINUM PROPELLANT (ROUND 4049)

A Micarta specimen ablated 1.016 inches at the stagnation point in 2.860 seconds when placed two inches from the nozzle exit of a 6C3-11.4 motor containing 16% aluminum propellant (Table II). The motor was fired at 727 psia with a mass flow rate of .50 lbm/in^2-sec at the nozzle exit. A second specimen ablated 0.136 inches in 2.748 seconds when placed two inches from the nozzle exit of 6C3-11.4 motor containing 0.5% aluminum propellant (RH-P-400)(Table II).

The heating and ablation rates on the calorimeter and test specimens were much more severe than expected, and it was obvious that the specified test duration of 5 seconds and a chamber pressure of 700 psia were unreasonable for these propellant formulations. To

obtain the desired ablation rate and calorimeter data the test motors would have to be fired at less severe conditions.

4.3.2 Formulation and Testing of Low-Flame-Temperature Propellants

With the approval of personnel of the Structures and Mechanics Laboratory propellant formulation work and further exploratory firings were carried out. The purpose was to redefine the test conditions such that measurable ablation rates would be obtained on the Micarta specimens with the low aluminum composition and at least 500 milliseconds of usable thermocouple data would be obtained with the highest aluminum composition.

Six firings were carried out in 6C5-11.4 motors with RH-P-390 and RH-P-391, relatively low-flame-temperature propellants containing 15.0% and 0.5% aluminum respectively, and with RH-P-401, a propellant containing 8.0% aluminum.

For the tests with the high aluminum compositions a two-dimensional copper specimen was made from 3-inch bar stock to substitute for the more expensive copper calorimeters (Fig. 6). A single Micarta specimen was used for three tests with low aluminum compositions. High-speed color movies were made of each firing.

A shock wave obscured the front of the copper specimens so that it was not possible to determine from the movies the time at which the surface started to melt. However, at low pressures the overall ablation rates (using the action time of the motors) were 0.066 in/sec and 0.205 in/sec for the cool 15% aluminum and the 8% aluminum compositions respectively (Table III). In comparison the ablation rate of the copper calorimeter with a high-flame-temperature, 16% aluminum composition was approximately 0.56 in/sec at 700 psia. It was estimated that the cool 15% aluminum composition would provide at least 500 milliseconds of usable thermocouple data.

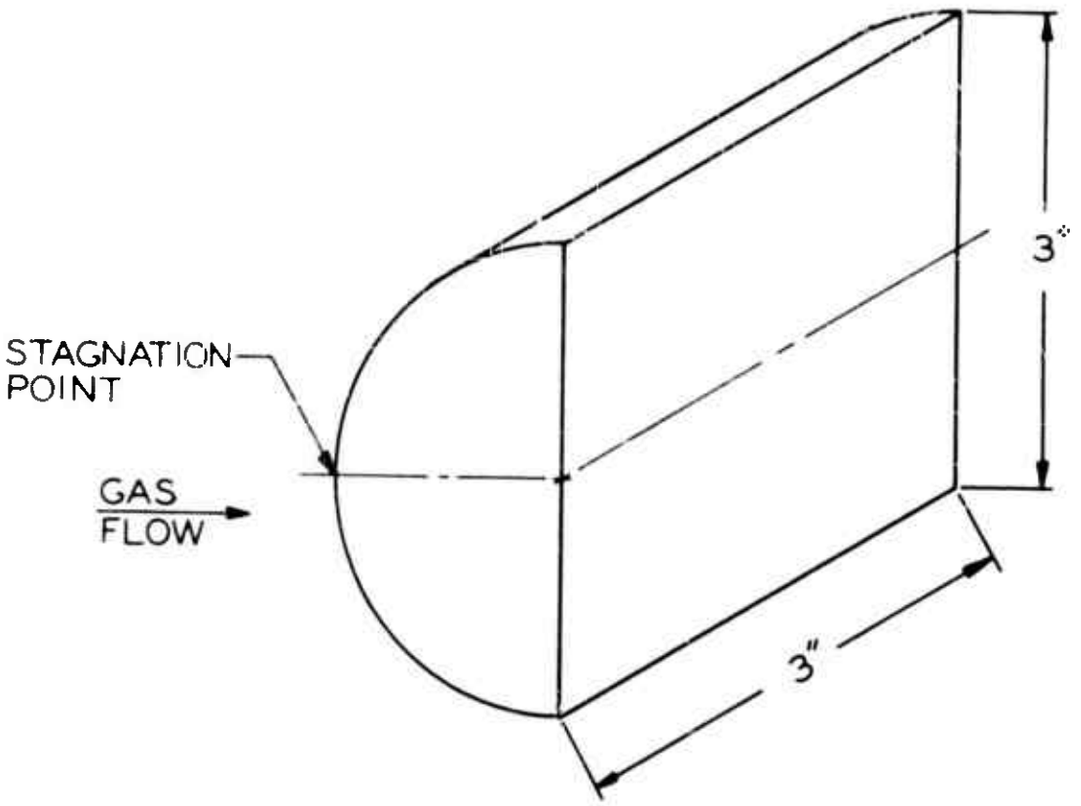

FIG. 6 TWO-DIMENSIONAL COPPER SPECIMEN

Table III

Performance of Carbon-Phenolic and Ablative Specimens with Low Plasma Temperature Propellants

Round Number	Propellant	Aluminum Content (%)	Motor Pressure (psia)	Exit Mass Flow Rate (lbm/in^2 sec)	Action Time (sec)	Expansion Ratio	Exit Mach Number	Type Specimen	Distance From Nozzle (in)	Specimen Length Before (in)	Specimen Length After (in)	Ablation Rate (in/sec)
6969	BH-P-[illegible]	15	1 [illegible]	0.39	3.209	7.89	5.11	3-D Copper	2.0	1.674	[illegible] 320	0.040
6995	BH-P-196	15	[illegible]0	0.50	3.078	10.60	5.91	3-D Copper	2.0	1.693	[illegible]	0.351
6621	BH-P-193	0.5	800	0.56	3.105	7.76	5.11	Micarta 299-3	2.0	1.770	1.666	0.036
6622	BH-P-193	0.5	991	0.69	3.752	6.71	5.00	Micarta 299-2	2.0	1.845	1.515	0.070
6996	BH-P-201	1	806	0.43	3.616	7.82	5.11	Micarta 299-2	2.0	2.130	1.770	0.029
6974	BH-P-201	1	991	0.53	3.399	5.99	4.68	3-D Copper	2.0	1.672	1.876	0.266

The effect of pressure on the ablation rate was marked. Increasing the pressure from 420 to 800 psia increased the copper ablation rate from 0.066 to 0.357 in/sec while increasing the pressure from 645 to 990 psia increased the Micarta ablation rate from 0.036 to 0.070 in/sec (Fig. 7). While there were not enough data points to provide valid extrapolation, it was evident that a measurable ablation rate could be obtained at pressures as low as 400 psia with the low aluminum compositions.

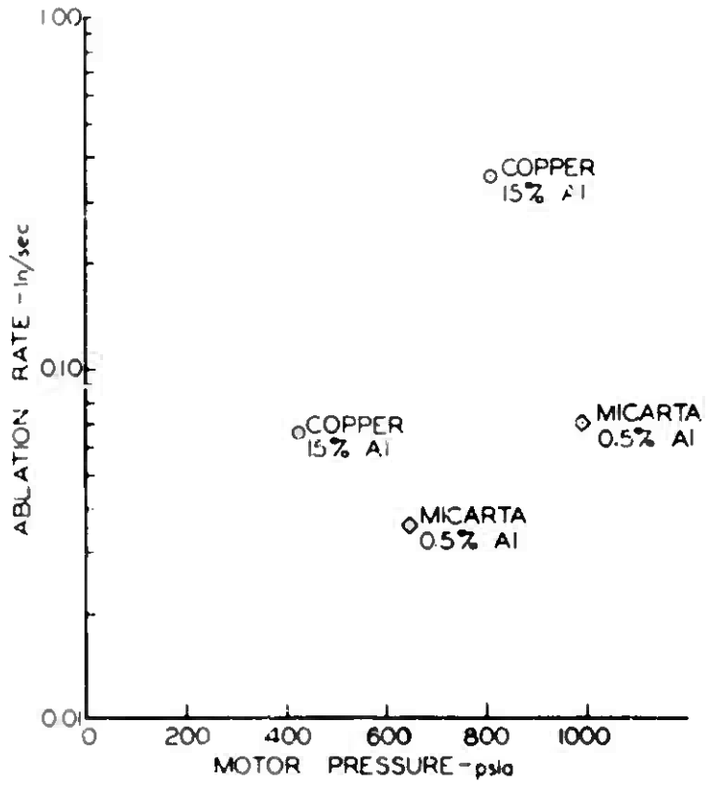

FIG. 7 ABLATION RATES WITH LOW-FLAME-TEMPERATURE PROPELLANTS

There were not enough firings to define the effect of aluminum content on the ablation rates, but the ablation rate with 8% aluminum propellant was about the same order of magnitude as with 16% aluminum propellant.

Some build-up of slag was observed in the nozzle after the firings with the cool 15% aluminum composition. The throat diameter before and after slag removal was 1.056 and 1.072 inches respectively for the 422 psia shot (Round 4394) and 0.832 and 0.844 inches for the 806 psia shot (Round 4395). For the hot 16% aluminum composition fired earlier there was no appreciable buildup. There was also no build-up during the firings with 8% aluminum propellant.

These exploratory firings indicated that the desired exposure conditions could be achieved either with high-flame-temperature propellants operating in the 400-500 psia range with aluminum contents of 0.5%, 6.0%, and 12.0%, or with cooler propellants operating at 500 psia with the original 0.5%, 8.0% and 16.0% aluminum content. The latter approach was taken.

5. DEVELOPMENT OF FINAL TEST PROPELLANTS AND HARDWARE

5.1 Characteristics of Test Propellants

The low-flame-temperature propellant RH-P-390 was modified by substituting 1% aluminum for 1% ammonium perchlorate to form a 16% aluminum composition, RH-P-407. Theoretical flame temperatures were calculated at chamber pressures of 550 psia for RH-P-407 and for several 0.5% and 8.0% aluminum compositions with varying amounts of di-n-propyl adipate, which served as a coolant. From these data the 0.5% and 8.0% aluminum compositions, RH-P-405 and RH-P-406, were formulated and additional computer runs were made to determine the flame temperatures. The maximum difference for the six cases was less than one per cent of the total temperature (Table IV).

Twelve 2C1.5-4 motors were fired to obtain P-K-r data (Fig. 8). These propellants, before curing, have a very high viscosity for a plastisol propellant, and to make the motor casting operations less difficult unground ammonium perchlorate was used. The larger particles of perchlorate and the di-n-propyl adipate made the motors hard to ignite. Surface roughening and a larger igniter were necessary to get good ignition.

It was not necessary to use end-burning charges with these propellants. The shorter firing times permitted use of 6C5-11.4 motors for the 8% and 16% aluminum compositions, and 6C4-11.4 motors for the 0.5% aluminum composition. The flow patterns from these symmetrical charges are uniform.

Table IV

Theoretical Thermochemical Properties of Test Propellants

	RH-P-405		RH-P-406		RH-P-407	
Chamber Pressure, psia	400	550	400	550	400	550
Exhaust Pressure, psia	14.7	14.7	14.7	14.7	14.7	14.7
Chamber Temperature, °K	2960	2979	2952	2964	2958	2970
Exhaust Temperature (frozen), °K	1625	1542	1632	1545	1655	1570
Exhaust Temperature (equil) °K	1793	1692	1727	1631	1747	1651
Exhaust Enthalpy (frozen), K cal/100 grams	-118	-122	-116	-120	-114	-118
Exhaust Enthalpy (equil), K cal/100 grams	-120	-124	-118	-122	-116	-120
Exhaust Specific Heat Ratio	1.22	1.23	1.22	1.23	1.22	1.22
Principle Components of Exhaust, moles/100 grams						
CO	0.55	0.53	1.11	1.21	1.51	1.51
CO_2	0.71	0.73	0.32	0.21	0.05	0.05
N_2	0.42	0.42	0.36	0.36	0.30	0.30
H_2	0.29	0.31	0.87	0.77	1.55	1.55
N_2O	1.38	1.36	0.84	0.93	0.17	0.17
HCl	0.40	0.40	0.34	0.32	0.27	0.27
Al_2O_3 (liquid)	0.01	0.01	0.15	0.15	0.30	0.30

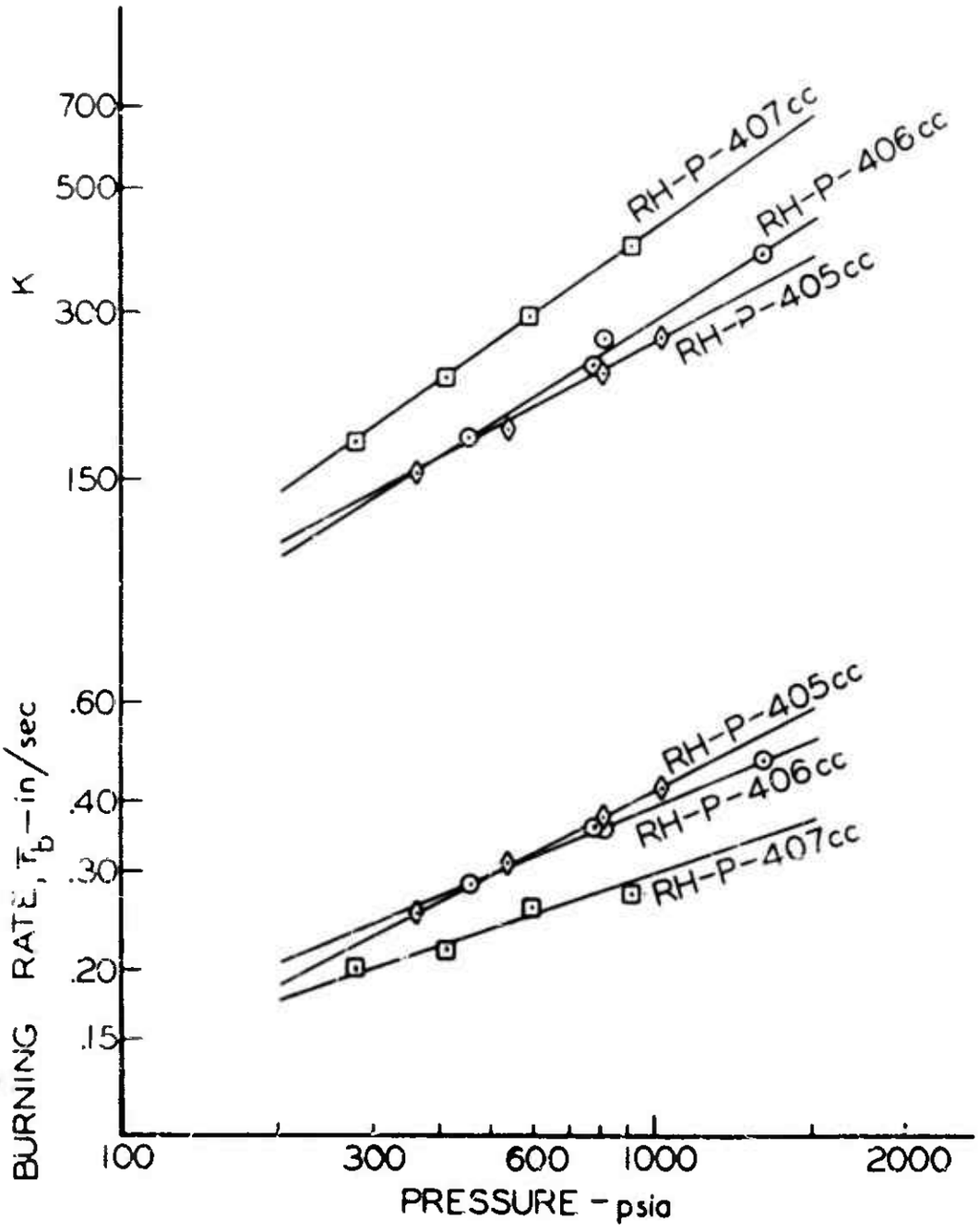

FIG. 8 PRESSURE-K-BURNING RATE RELATIONSHIPS FOR TEST PROPELLANTS

6. DESCRIPTION AND RESULTS OF TEST FIRINGS

6.1 Calorimeter Tests

Six firings were made with copper calorimeters immersed in the exhaust stream of 6-inch motors. The tip of the calorimeters was positioned two inches from the nozzle exit. There was one test at 400 and 550 psia for each of the three aluminum contents. During these tests the response of eight thermocouples in each calorimeter was recorded in analog and digital form.

Also recorded was the output of a heat flux transducer. During the first firing (Round 4955) the sensing face of the heat flux transducer was positioned perpendicular to and four inches away from the centerline of the exhaust stream at a point one inch downstream from the nozzle. After the firing the window of the gauge was clouded (possibly by the blast from the igniter). In all other firings the transducer face was located five inches from the centerline of the exhaust stream and was shielded from the igniter blast by a 3 × 5-inch paper card. The card was removed immediately after ignition and this quick-fix remedy seemed to prevent clouding for the low aluminum firings. However, some pits and spots were observed on the window after the 16% aluminum firings.

The chamber pressure of each firing was measured at the head-end of the motor case with a calibrated strain-gage-type transducer and recorded on an analog trace and in digital form. In five of the six tests the average pressures, $\overline{P}_b$, were close to the nominal values of 400 and 550 psia (Table V). The burning times were about 3 seconds for the motors with 0.5% aluminum propellant, 1.5 seconds for motors with 8% aluminum propellant, and 2 seconds for motors with 16% aluminum propellant. Calorimeter No. 1 was not damaged in the test with 0.5% aluminum and was subsequently reused. The others each sustained some degree of melting at the stagnation point. The mass flux at the nozzle exit (based on the action time t_a) exceeded the required value of 0.5 lbm/in^2-sec (Table V).

Table V

Firing Conditions for Calorimeter Tests

Propellant Aluminum Content	Round	Calorimeter Number	t_b (sec)	t_a (sec)	$\bar{P}_b$ (psia)	$\bar{P}_a$ (psia)	$\dot{m}/A_e$ (lbm/in^2-sec)	Expansion Ratio	Theoretical Exit Mach Number
0.5	4954[a]	1	3.443	3.543	394	389	0.59	4.31	2.68
0.5	4957[a]	2	2.878	3.071	561	545	0.67	5.50	2.92
8.0	4956[b]	3	1.626	1.907	399	372	0.63	4.57	2.74
8.0	4955[b]	4	1.525	1.666	560	538	0.66	5.77	2.89
16.0	4959[b]	5	2.346	2.476	388	381	0.58	4.58	2.72
16.0	4958[b]	1	2.148	2.279	518	506	0.63	5.67	2.87

[a] Calorimeter located two inches from nozzle of a 6C4-11.4 motor.
[b] Calorimeter located two inches from nozzle of a 6C5-11.4 motor.

Appendix A describes the thermocouple locations in detail and presents the temperature-time measurements in tabular form. The thermocouple data, heat flux measurements, and motor pressure are also plotted as a function of time in Figs. 9 through 14. The 1 second delay was to allow the movie camera to get up to speed before the firing occurred. Comparing the data in these figures shows that the heating rate increased at the higher pressures and aluminum contents. A composite plot of the response of the thermocouples located 0.1 inch from the calorimeter surface more clearly shows this effect (Fig. 15). The heat flux measurements also confirm this trend, although the data were not as consistent (Fig. 16).

These results were not analyzed further since the primary purpose of the project was to provide raw data for the Structures and Mechanics Laboratory.

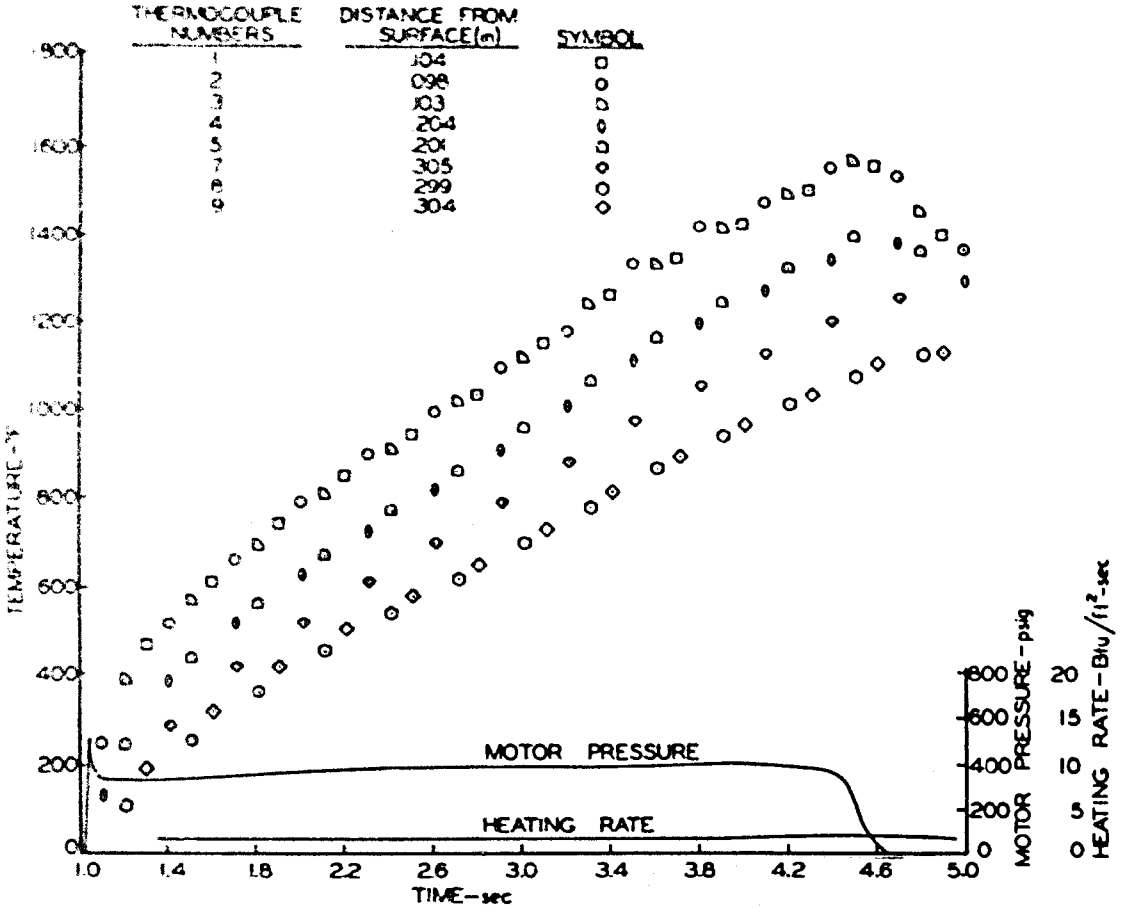

FIG. 9 TEMPERATURE, MOTOR PRESSURE, AND HEATING RATE MEASUREMENTS FROM A FIRING WITH 0.5% ALUMINUM PROPELLANT (ROUND 4954)

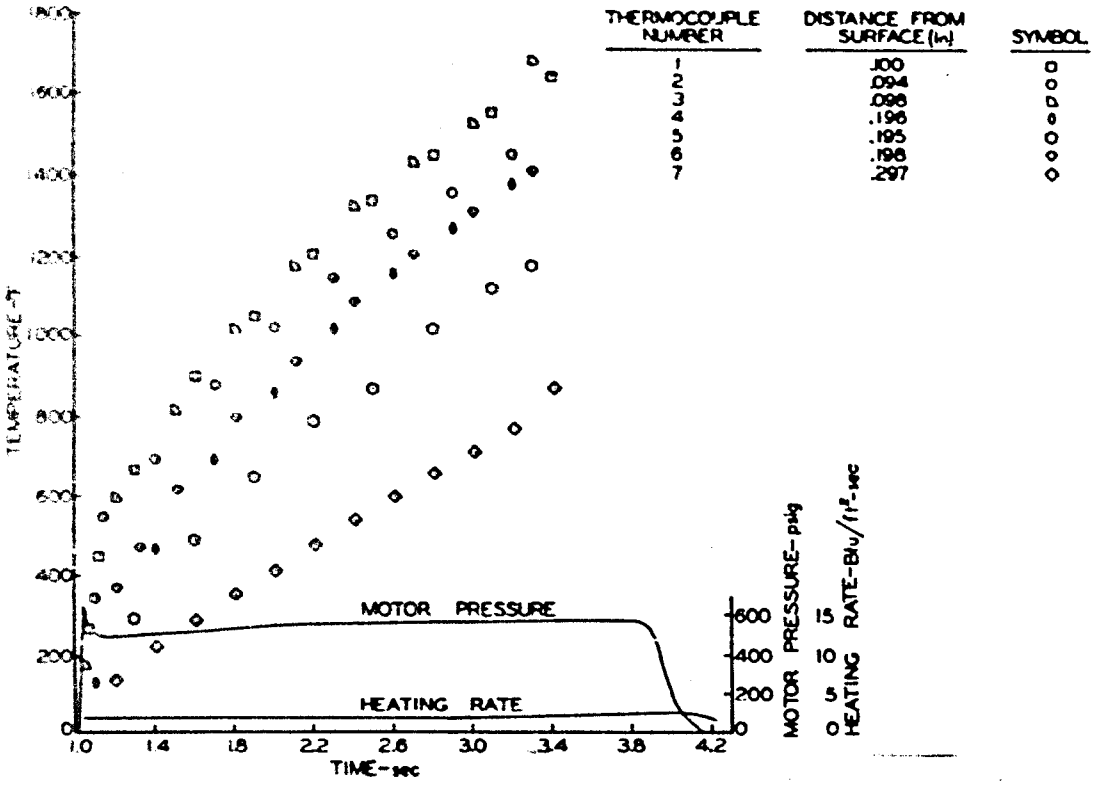

FIG. 10 TEMPERATURE, MOTOR PRESSURE, AND HEATING RATE MEASUREMENTS FROM A FIRING WITH 0.5% ALUMINUM PROPELLANT (ROUND 4957)

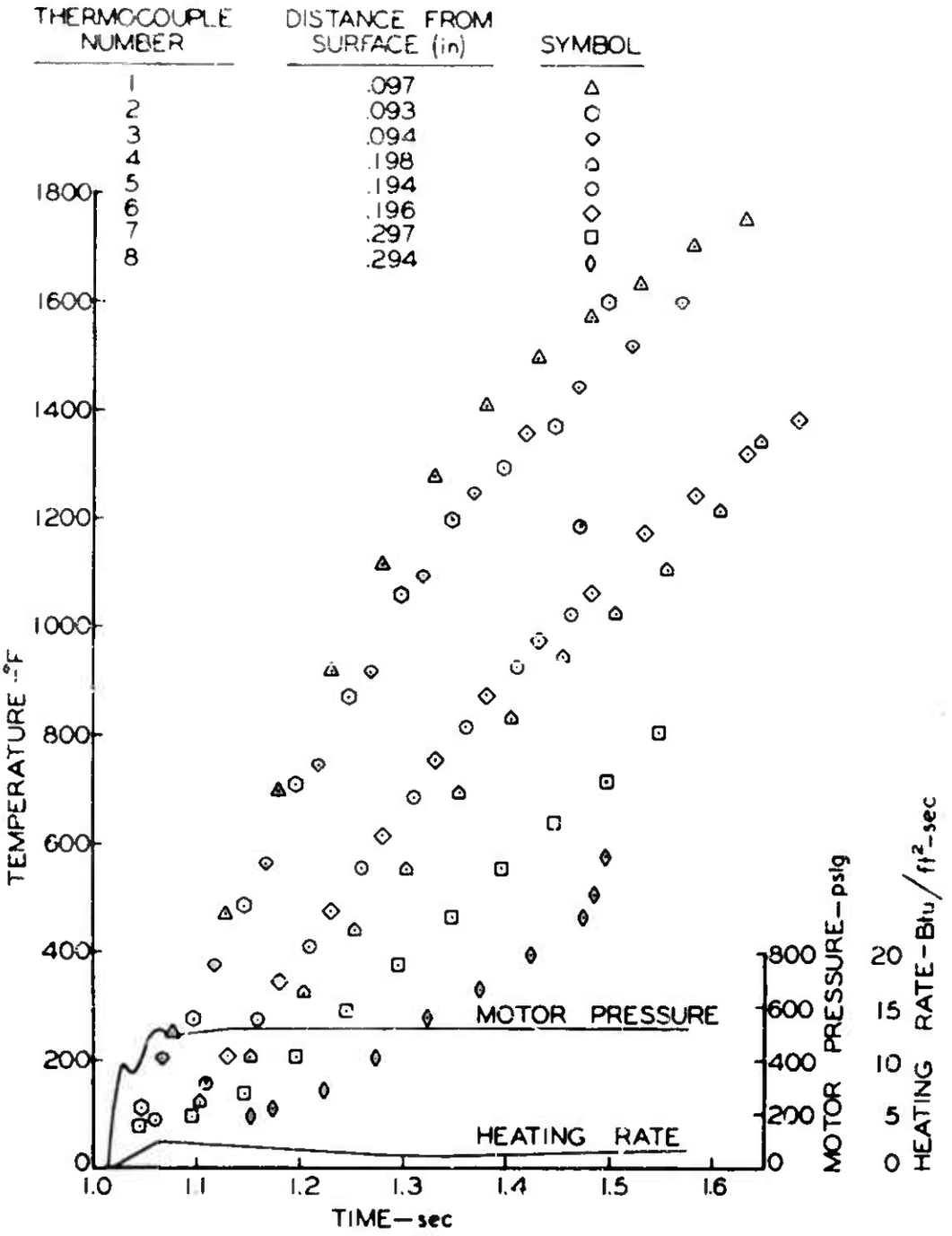

FIG. 11 TEMPERATURE, MOTOR PRESSURE, AND HEATING RATE MEASUREMENTS FROM A FIRING WITH 8% ALUMINUM PROPELLANT (ROUND 4955)

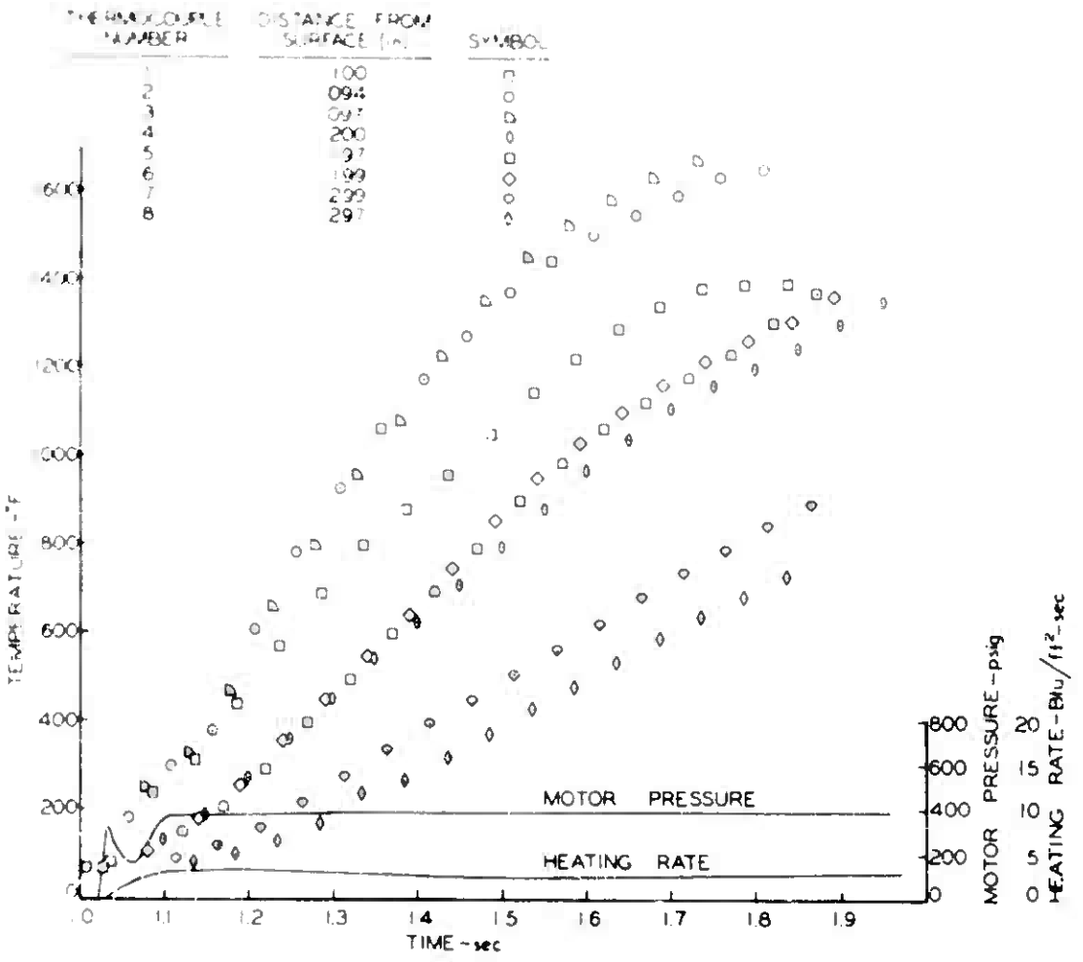

FIG. 12 TEMPERATURE, MOTOR PRESSURE, AND HEATING RATE MEASUREMENTS FROM A FIRING WITH 8% ALUMINUM PROPELLANT (ROUND 4956)

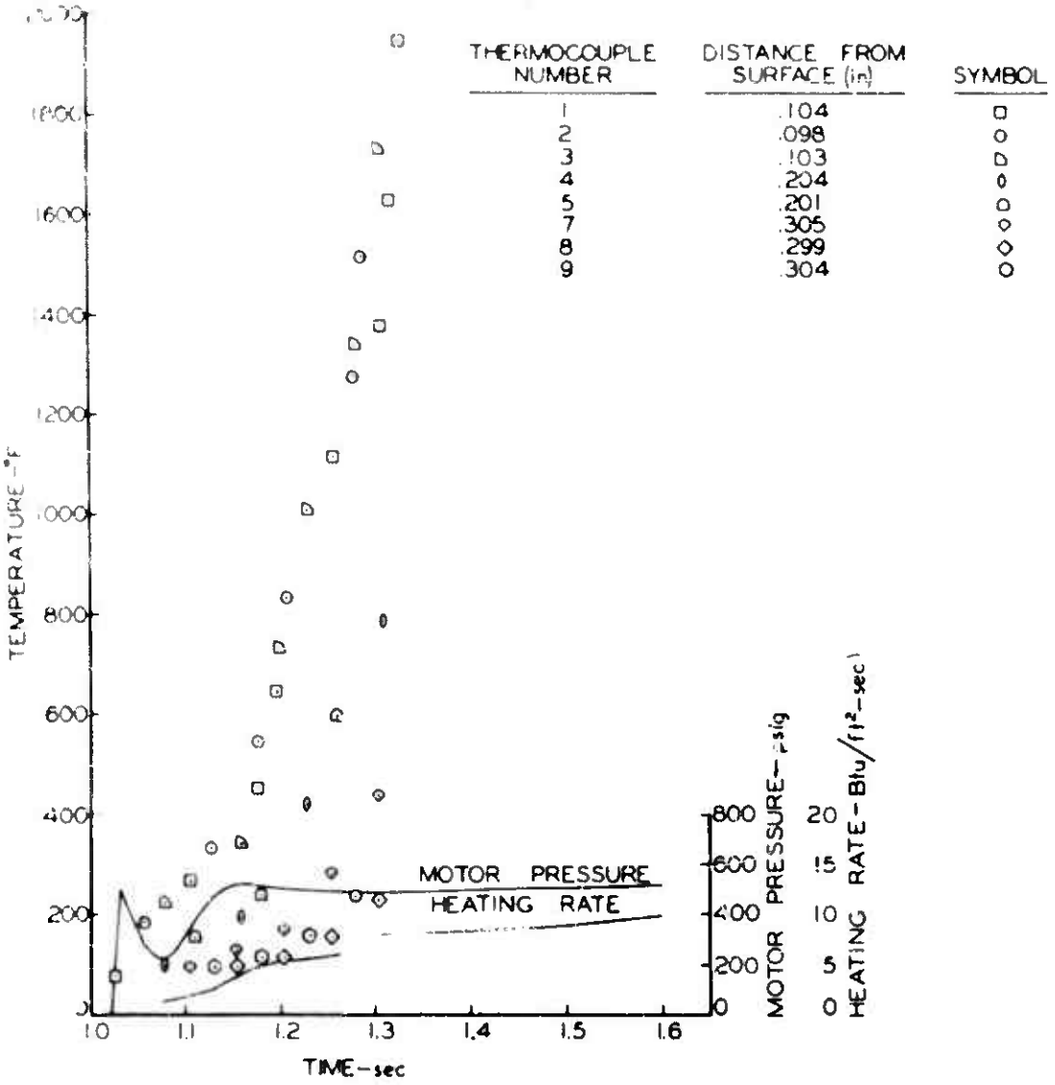

FIG. 13 TEMPERATURE, MOTOR PRESSURE, AND HEATING RATE MEASUREMENTS FROM A FIRING WITH 16% ALUMINUM PROPELLANT (ROUND 4958)

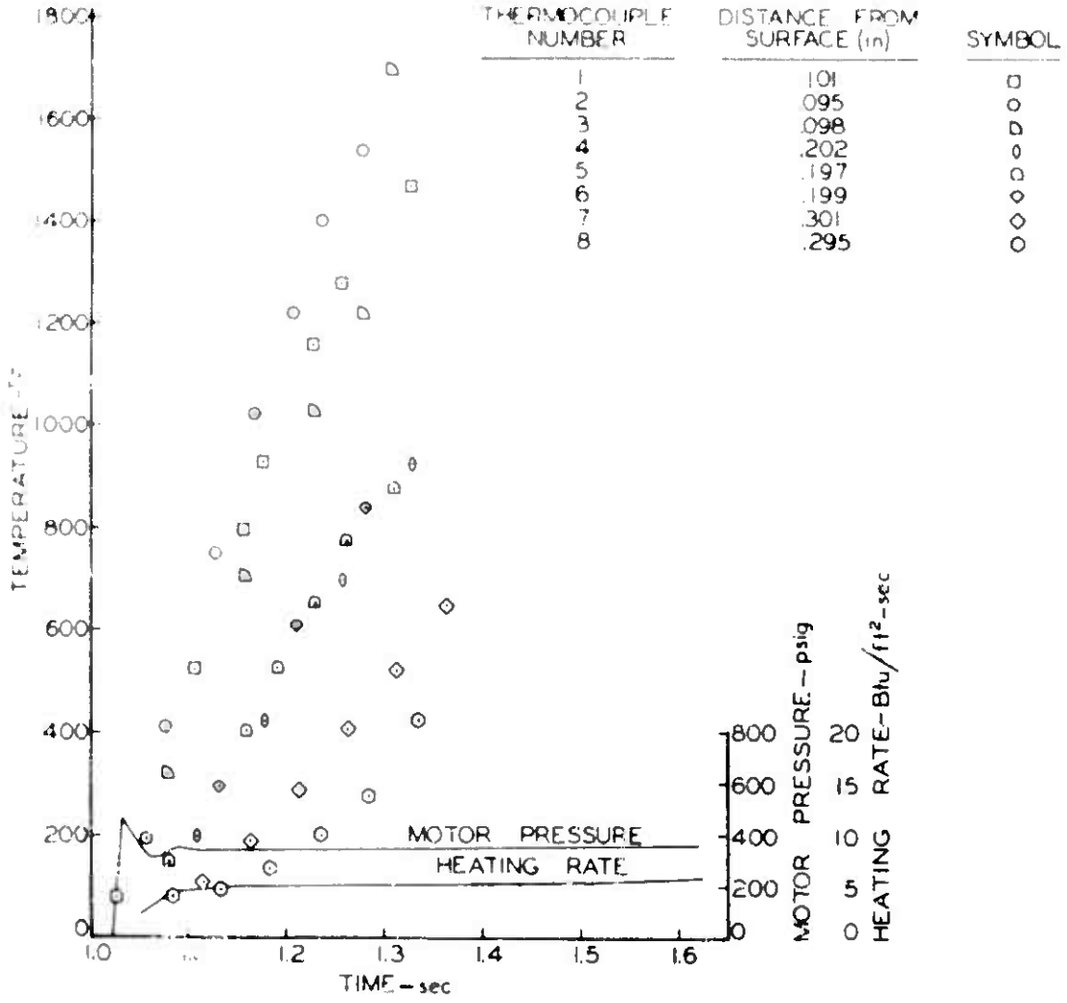

FIG. 14 TEMPERATURE, MOTOR PRESSURE, AND HEATING RATE MEASUREMENTS FROM A FIRING WITH 16% ALUMINUM PROPELLANT (ROUND 4959)

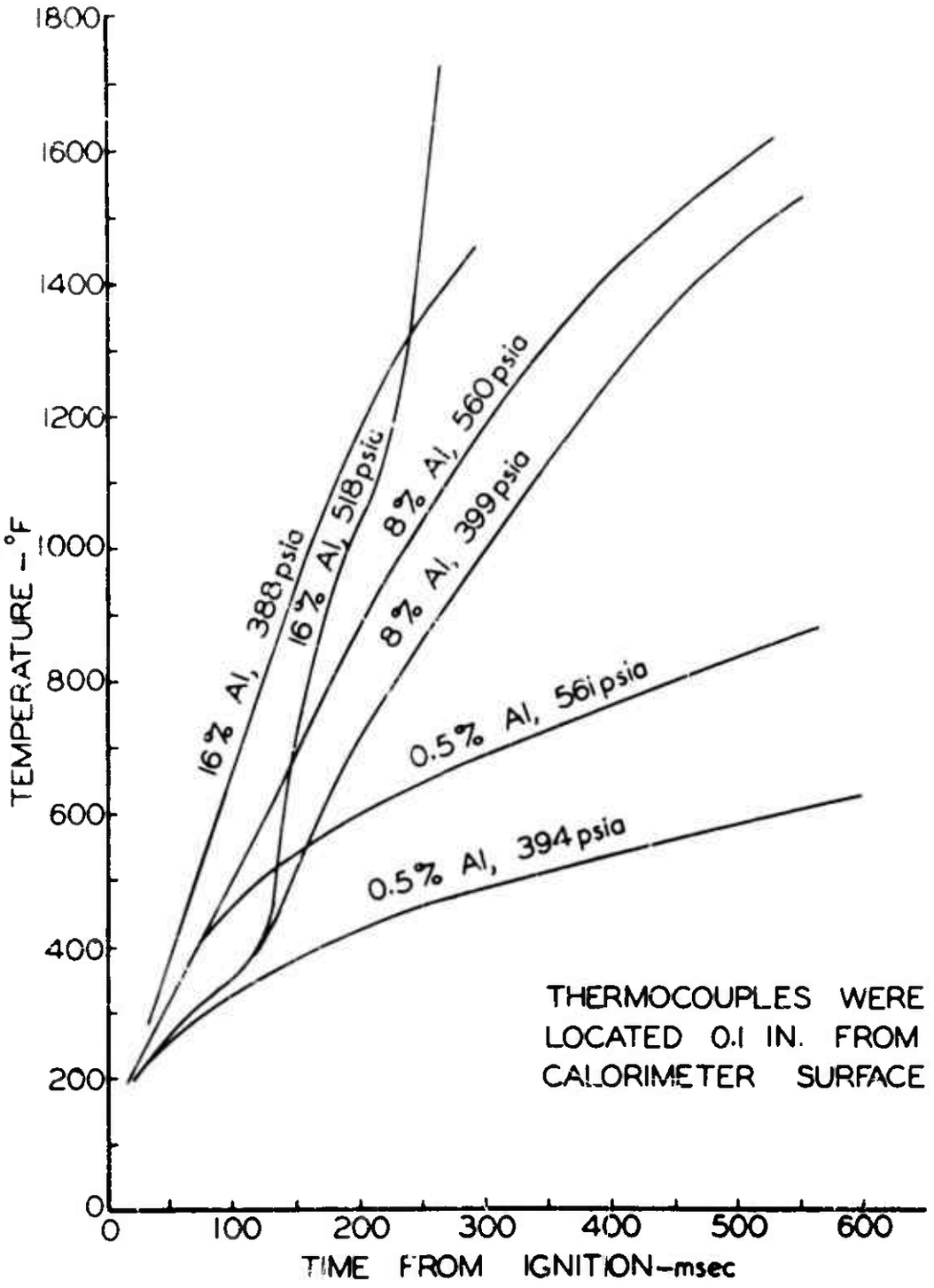

FIG. 15 THERMOCOUPLE RESPONSE AS A FUNCTION OF ALUMINUM IN PROPELLANT AND MOTOR PRESSURE

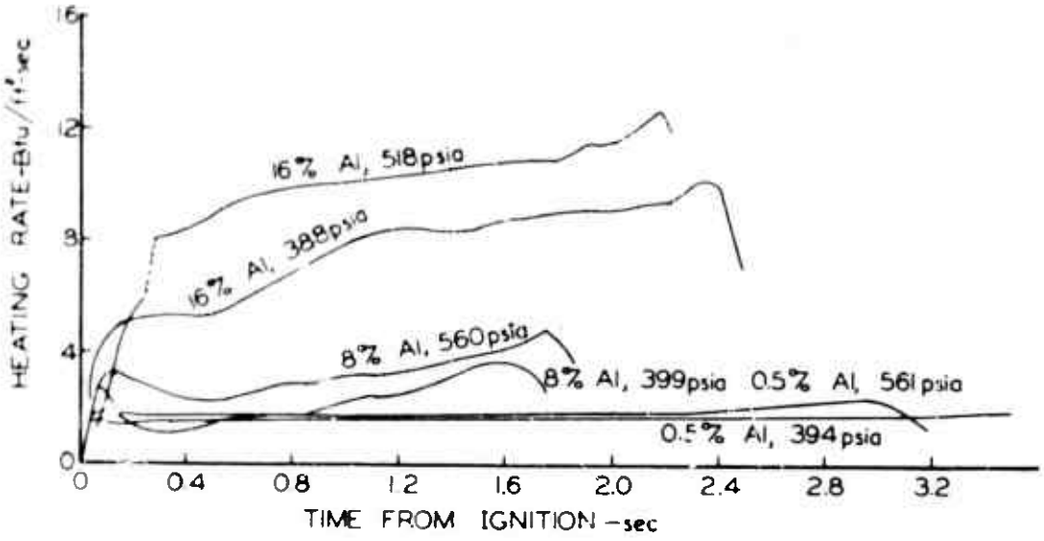

FIG. 16 RADIATION HEAT FLUX WITH CALORIMETERS IMMERSED IN THE EXHAUST STREAM

6.2 Tests on Ablative Specimens

Thirteen firings were carried out with ablative specimens immersed in the exhaust gases of 6-inch motors. The stagnation point of the specimen was positioned two inches from the nozzle exit. There were firings at 400 and 550 psia chamber pressures for each of the three aluminum contents.

Heat flux measurements were made during four of these ablative firings (Rounds 4969, 4960, 4971, and 4984) with a more sensitive transducer. Its position was the same with respect to the nozzle and specimen as described in Section 6.1. The heating rates were higher with an ablative specimen in the exhaust stream than with a calorimeter in the exhausts (Fig. 17).

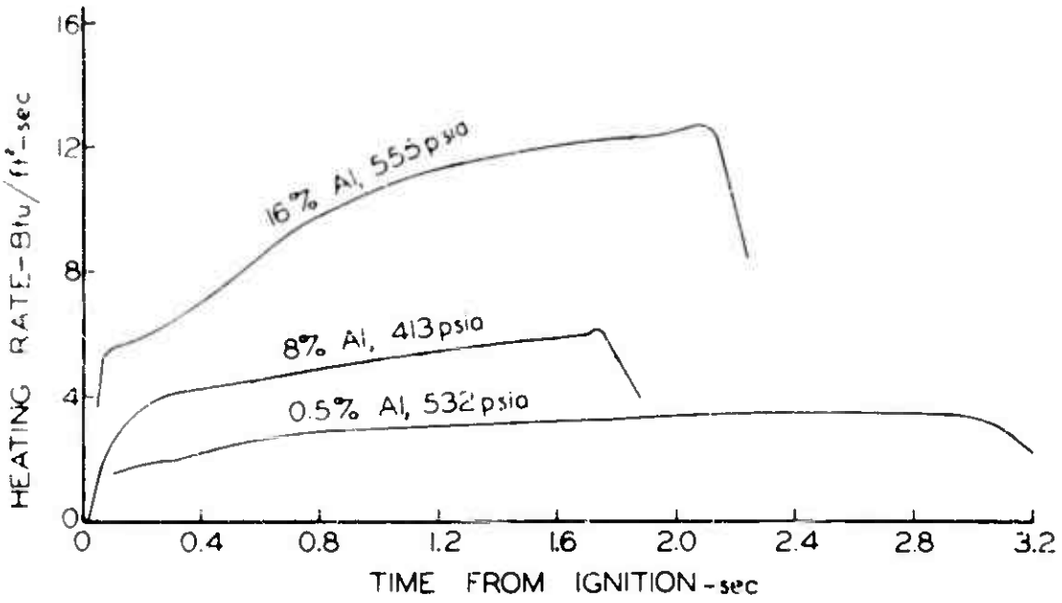

FIG. 17 RADIATION HEAT FLUX WITH ABLATIVE SPECIMENS IMMERSED IN THE EXHAUST STREAM

The motor chamber pressure was measured at the head-end of the case with a calibrated transducer and recorded on an analog trace and in digital form. There were duplicate firings at each condition for the 0.5% and 16% aluminum compositions. In general the average pressures, $\overline{P}_b$, were close to the nominal values of 400 and 550 psia (Table VI).

Thrust measurements were made during nine of the firings. The ratio of measured to calculated specific impulse at test conditions, η, was lower than expected for the composition containing 16% aluminum (Table VI). This correlates with the greater amount of slag build-up in the nozzles of rounds containing that propellant.

The mass flux at the nozzle exit (based on t_a) exceeded the required value of 0.5 lbm/in^2-sec in each case.

Table VI

Firing Conditions and Results for Ablative Specimens Tests*

*Ablative Specimens from Various Propellants

**Thermal Soot Indicated

***Recession Reading Taken on Wall Specimen was Slightly Off Vertical and at an Angle with the Ambient Stream.

Measurable changes in specimen weight and length occurred during each firing (Table VI, Fig. 18). The ablation rates, which were calculated at the stagnation point using the action time t_a, were a direct function of pressure and aluminum content of the propellant. The values ranged from 0.057 in/sec at 400 psia and 0.5% aluminum content to 0.378 in/sec at 550 psia and 16% aluminum content (Table VI).

The 1500 frame/second movies taken of each ablative specimen during the firing were spectacular. The specimen was clearly visible through the exhaust gases of the 0.5% and 8% compositions. Droplets of melted glass could be seen flowing back over the surface and the change in shape and length was obvious. The original films were transmitted to the Structures and Mechanics Laboratory for analysis but a good print is available on loan from the author.

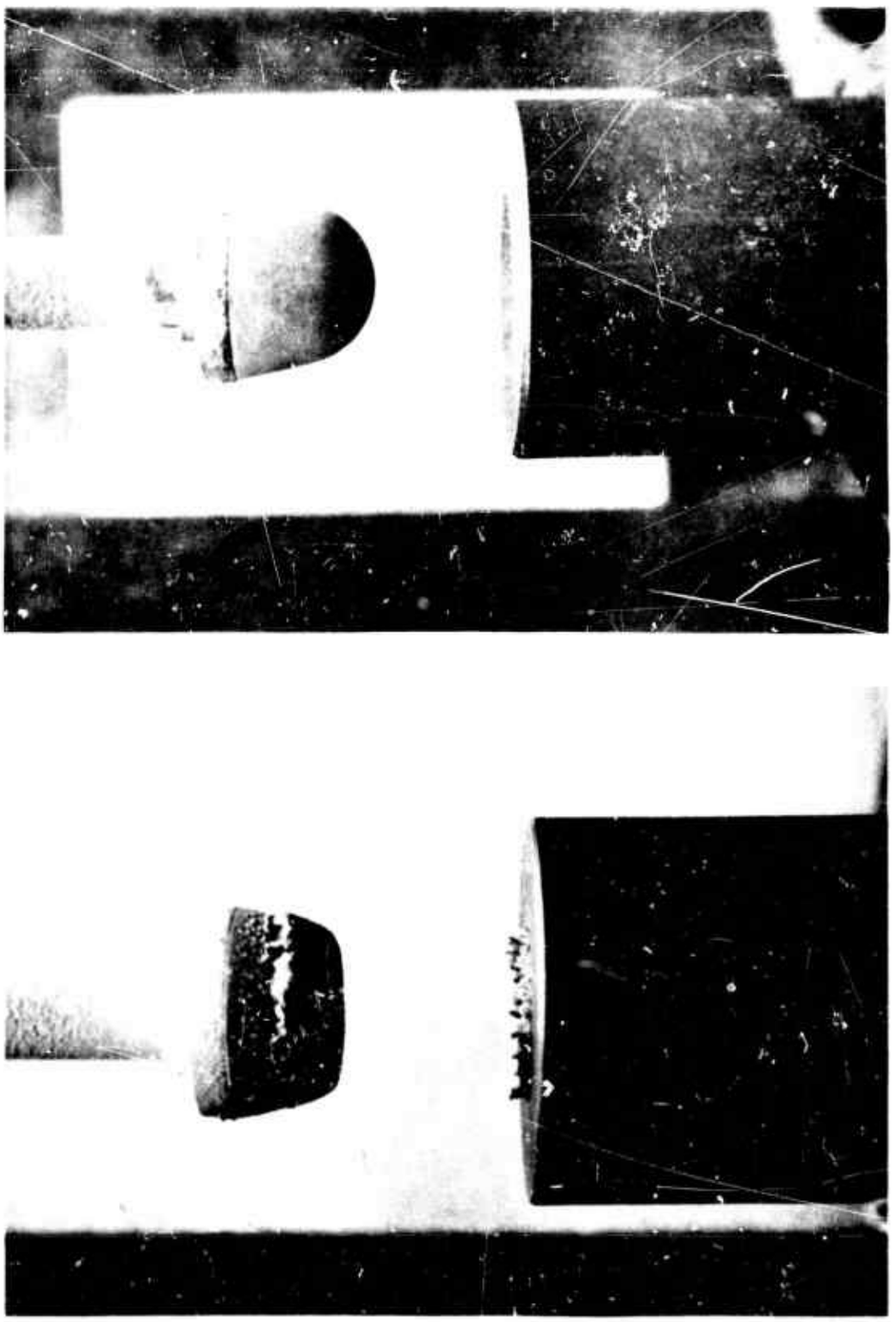

FIG. 18 CHANGE IN ABLATIVE SPECIMEN SHAPE DURING A 2.37-SECOND FIRING WITH A 16% ALUMINUM PROPELLANT

7. SUMMARY

A test program for determining the effect of solid particles on heating and erosion rate of ablative-type protective materials has been successfully carried out. Extensive formulation work was necessary to develop propellants which would provide suitable test conditions on both copper calorimeters and ablative specimens. Testing was carried out at nominal chamber pressures of 400 and 550 psia and with propellants having aluminum contents of 0.5%, 8%, and 16%. The flame temperatures of these propellants were within 1% of 2965°K.

Raw data for calculating heating rates on the specimens were obtained from copper calorimeters instrumented with thermocouples. The temperature readings were recorded in digital form and printed out in convenient tabular form. Ablation rates were obtained on 13 specimens and reproducibility of data on identical firings was excellent.

Close-up color movies taken at 1500 frames/second showed the details of specimen melting and ablation.

APPENDIX A

DESCRIPTION OF COPPER CALORIMETERS, DATA ACQUISITION SET-UP, AND DATA PRINT-OUT

The ten 30-gage chromel-alumel thermocouples were located at different depths from the calorimeter surface in a $\frac{3}{8}$-inch diameter copper plug. The distance from the leading edge along the side of the $\frac{3}{8}$-inch plug to the centerline of the 0.024-inch diameter hole is given in Table A-I.

The reference junction of the thermocouples was maintained at 150°F ± 1°. The response of the thermocouples was recorded on paper by a rapid-response oscillograph; the signal was also fed into a TRW 230 computer in digital form. The computer determined the temperature from a third degree polynomial equation representing the temperature vs millivolt relationship for chromel-alumel thermocouples and printed out the results in degrees Fahrenheit. Above 200°F the maximum difference between the polynomial and the temperature-millivolt plot was 1.7°F.

The computer print-out of the thermocouple readings for each firing is given in Tables A-II through A-VII. The computer received data from ten multiplexer channels during these tests, and a channel was sampled every millisecond beginning with the Number 1 Multiplexer channel and taking each channel in order. Zero time was the beginning of the firing sequence. The time at which the Number 1 multiplexer channel was sampled is given in the first column of the print-out sheet. The multiplexer channel number is listed in the heading of each print-out. The numbers go from 1 thru 6, skip 7 and 8, and then pick-up at 9 and 10 on the print-out; the times at which the readings shown in the first line were recorded are 735.1, 736.1, 737.1, 738.1, 739.1, 740.1, 743.1, and 744.1 msec.

Ignition of the motors occurred at times varying from 1018 to 1026 msec after the start of the timing sequence. These approximate times are marked in the margin of the print-out sheets.

Table AI

Distance from Leading Edge to Centerline of Thermocouple Holes (in)

Calorimeter	1	2	3	4	5	6	7	8	9	10
1	0.104	0.098	0.103	0.204	0.201	0.203	0.305	0.299	0.304	0.401
2	0.100	0.094	0.098	0.196	0.195	0.198	0.297	0.288	0.298	0.394
3	0.100	0.094	0.097	0.200	0.197	0.199	0.299	0.297	0.300	0.398
4	0.097	0.093	0.094	0.198	0.194	0.196	0.297	0.294	0.296	0.395
5	0.101	0.095	0.098	0.202	0.197	0.199	0.301	0.295	0.299	0.395

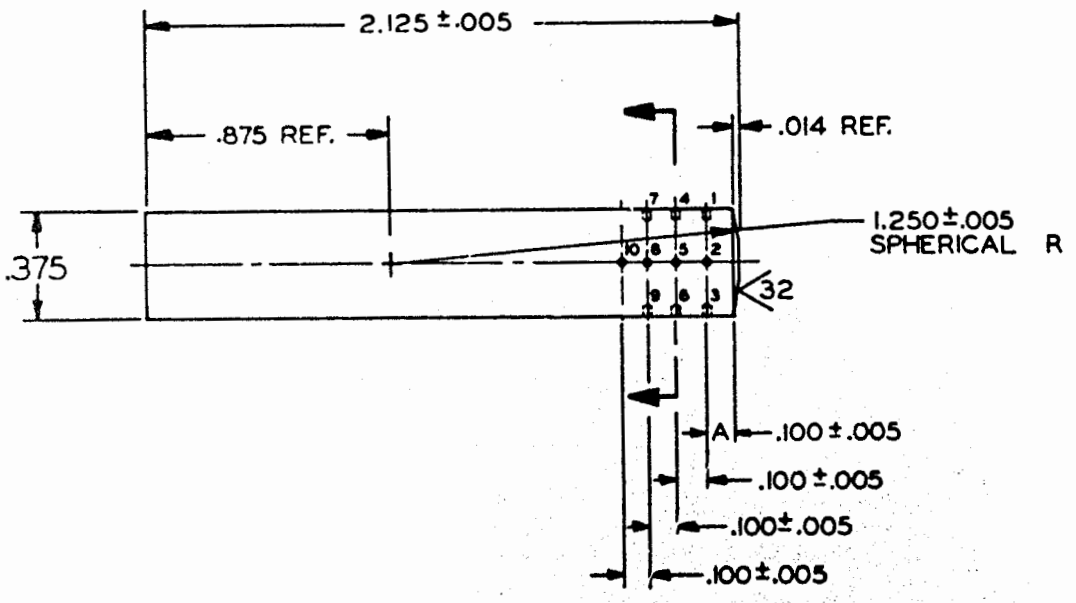

FIG. A-1 CALORIMETER PLUG

Table A-II

Temperature Data Print-Out for Round 4954

Thermocouple No.		1	2	3	4	5	9	7	8
Multiplexer Channel		01	02	03	04	05	06	09	10
	Time (msec)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)
	735.1	70.935	71.333	71.294	71.258	71.825	70.979	71.277	70.960
	745.1	70.991	71.113	71.294	71.339	71.391	71.085	71.277	71.015
	755.1	71.018	71.278	71.294	71.297	71.134	71.085	71.223	70.960
	765.1	70.991	71.113	71.874	71.285	71.080	70.975	71.387	71.078
	775.1	70.991	71.223	71.239	71.285	71.188	71.194	71.113	70.795
	785.1	70.880	71.113	71.294	71.175	70.971	70.920	71.277	70.960
	795.1	70.935	71.278	71.294	71.339	71.324	71.030	71.332	70.960
	805.1	70.935	71.278	71.239	71.283	71.188	71.085	71.277	70.850
	815.1	70.991	71.113	71.129	71.230	71.188	70.975	71.387	71.070
	825.1	71.046	71.278	71.184	71.066	71.243	71.194	71.059	70.850
	835.1	70.935	71.168	71.129	71.121	71.080	71.030	71.277	70.960
	845.1	71.101	71.223	71.294	71.175	71.297	71.251	71.113	70.960
	855.1	70.935	71.333	71.294	71.121	71.025	71.085	71.223	70.905
	865.1	71.046	71.223	71.184	71.121	71.188	71.030	71.332	71.070
	875.1	71.101	71.223	71.239	71.121	71.243	71.301	71.059	70.850
	885.1	70.880	71.113	71.184	71.230	71.188	70.975	71.332	70.960
	895.1	70.880	71.140	71.184	71.285	71.270	71.140	71.223	70.905
	905.1	70.935	71.278	71.294	71.175	71.297	71.140	71.223	70.850
	915.1	70.991	71.113	71.184	71.175	71.188	70.975	71.277	71.070
	925.1	71.101	71.278	71.484	71.339	71.243	71.251	71.168	70.795
	935.1	70.880	71.168	71.184	71.175	71.188	70.975	71.332	71.015
	945.1	71.101	71.223	71.184	71.205	71.243	71.140	71.168	70.905
	955.1	71.101	71.223	71.239	71.121	71.188	71.030	71.332	70.685
	965.1	70.935	71.223	71.129	71.285	71.080	70.920	71.332	71.125
	975.1	71.046	71.333	71.294	71.230	71.297	71.194	71.059	70.741
	985.1	70.935	71.168	71.184	71.121	70.971	70.865	71.277	71.070
	995.1	71.101	71.113	71.349	71.175	71.351	71.199	71.223	71.015
	1005.1	70.991	71.168	71.239	71.121	71.080	71.140	71.113	70.905
	1015.1	70.880	71.030	71.674	71.066	71.080	70.920	71.223	70.960
Ignition	1025.1	71.046	71.333	71.239	71.175	71.215	71.194	71.084	70.799
	1035.1	72.263	79.158	72.776	70.957	70.618	70.424	70.840	70.631
	1045.1	89.154	102.136	92.659	70.464	70.888	69.693	70.184	70.301
	1055.1	120.977	136.592	129.218	74.565	76.129	78.788	71.059	70.521
	1065.1	156.186	168.196	166.357	82.212	85.212	71.981	72.426	71.070
	1075.1	189.447	192.984	198.849	91.118	95.523	72.737	74.448	71.289
	1085.1	218.341	213.652	225.135	105.252	107.164	74.664	78.491	71.619
	1095.1	242.856	231.683	247.524	117.981	120.287	77.698	83.821	72.714
	1105.1	263.240	245.552	266.752	130.738	132.144	81.188	88.911	74.387
	1115.1	280.931	263.484	284.227	144.138	144.726	84.782	95.556	76.885
	1125.1	296.796	288.303	300.282	156.860	156.877	89.229	102.138	78.929
	1135.1	310.923	295.120	313.665	169.714	168.478	93.788	109.745	81.817
	1145.1	325.019	307.424	325.915	181.092	179.612	98.607	116.419	83.848
	1155.1	337.484	320.387	337.776	191.911	191.218	103.869	123.464	86.056
	1165.1	349.690	332.378	348.293	203.618	202.388	109.227	131.689	92.761
	1175.1	360.912	343.778	358.557	214.342	212.895	114.984	139.839	96.477
	1185.1	370.275	354.292	367.881	224.968	222.643	120.699	145.947	100.900
	1195.1	380.388	365.396	376.251	233.147	232.312	126.971	153.782	105.319
	1205.1	389.119	375.145	385.882	244.391	242.864	133.617	161.889	109.971

1215.1	387.994	384.828	383.834	283.447	251.330	134.711	169.306	114.526
1225.1	405.224	399.548	401.141	282.597	259.741	140.451	176.250	118.936
1235.1	414.038	411.863	409.194	291.409	268.151	142.259	184.110	124.420
1245.1	421.492	421.938	420.372	299.622	276.335	150.062	190.256	129.100
1255.1	428.945	429.015	424.400	244.574	284.496	153.480	197.380	133.876
1265.1	438.235	437.419	431.592	284.710	292.381	159.169	204.057	138.865
1275.1	445.212	414.935	434.721	301.596	300.632	174.840	210.726	143.579
1285.1	447.910	441.830	441.257	309.294	307.916	179.894	217.228	148.884
1295.1	454.152	448.997	452.861	315.869	314.935	185.366	223.829	153.967
1305.1	464.285	455.822	459.467	322.627	321.574	190.814	229.997	158.722
1315.1	469.970	462.109	466.461	328.655	328.228	195.931	236.371	163.635
1325.1	474.822	469.114	473.199	335.971	335.294	201.260	242.738	168.220
1335.1	480.919	475.447	479.116	342.176	341.722	206.206	248.940	173.266
1345.1	488.967	481.774	484.923	347.420	348.044	209.994	254.288	178.294
1355.1	492.054	488.148	491.179	352.748	353.739	212.974	259.579	182.921
1365.1	497.579	494.452	498.914	358.620	359.999	217.750	265.235	187.920
1375.1	503.896	499.988	502.756	364.379	365.992	222.736	270.938	192.109
1385.1	508.193	504.992	507.928	369.980	371.467	227.230	276.328	197.288
1395.1	513.183	510.829	513.862	375.633	377.450	232.321	281.591	201.712
1405.1	518.048	516.498	519.077	380.824	382.656	236.867	286.858	206.320
1415.1	523.145	521.423	523.982	385.934	388.218	241.410	292.278	210.924
1425.1	528.136	527.304	529.293	391.170	393.622	245.736	296.800	215.097
1435.1	532.712	532.441	534.090	396.505	398.970	250.112	301.949	219.855
1445.1	537.595	537.676	539.543	401.319	404.159	254.378	307.093	224.235
1455.1	542.166	542.887	544.036	406.154	408.857	258.428	311.857	228.718
1465.1	547.043	547.896	548.714	410.237	414.117	262.315	316.217	233.198
1475.1	551.712	552.039	554.064	415.170	419.090	266.626	320.408	236.929
1485.1	[illegible]	[illegible]	558.999	420.074	423.906	269.817	325.642	241.403
1495.1	561.194	563.320	563.779	424.614	429.180	273.910	329.304	245.448
1505.1	565.998	568.224	568.907	429.395	433.477	277.691	334.217	249.755
1515.1	570.208	573.330	573.330	433.787	438.565	281.769	338.291	254.060
1525.1	575.089	578.019	577.848	438.077	443.317	285.641	342.885	257.937
1535.1	579.313	582.642	582.212	442.845	447.887	289.511	346.745	261.971
1545.1	584.229	587.719	586.624	447.472	452.429	293.485	351.333	265.949
1555.1	588.911	592.135	591.541	451.840	456.968	297.350	355.240	269.818
1565.1	592.992	597.004	595.945	456.569	461.759	301.425	359.770	274.214
1575.1	597.495	601.922	599.999	460.261	466.037	305.021	363.360	277.179
1585.1	602.039	606.604	604.280	464.313	470.161	307.717	367.676	281.676
1595.1	606.369	611.242	608.349	468.235	474.994	311.203	371.386	285.087
1605.1	610.853	616.051	612.649	472.770	479.290	314.583	375.289	288.853
1615.1	615.336	620.554	616.387	476.842	483.534	318.066	379.102	292.455
1625.1	619.460	624.852	620.783	480.962	487.698	321.494	383.201	295.832
1635.1	623.887	629.452	624.823	485.259	491.708	325.131	387.141	299.892
1645.1	628.058	633.898	629.366	489.810	496.928	328.925	391.494	303.373
1655.1	632.481	638.442	633.504	493.438	500.255	332.408	394.705	306.983
1665.1	636.750	642.279	637.938	497.626	504.588	335.399	398.949	310.641
1675.1	641.271	646.820	641.471	501.174	508.741	339.187	402.158	313.508
1685.1	645.283	650.694	646.107	505.842	512.462	342.341	406.138	317.038
1695.1	649.587	655.361	649.935	509.514	516.839	345.651	409.962	320.635
1705.1	653.706	659.372	653.717	513.234	520.602	349.012	413.287	324.313
1715.1	658.067	663.704	657.251	516.953	524.272	351.637	417.242	327.726
1725.1	662.224	667.832	661.159	520.671	528.916	355.209	420.389	330.885
1735.1	666.379	671.809	664.352	524.895	532.202	358.142	424.915	334.442
1745.1	670.633	676.135	668.954	528.558	536.745	361.444	427.942	337.378
1755.1	674.684	680.108	672.673	532.448	539.974	364.787	431.471	340.941
1765.1	678.732	684.341	676.140	536.336	544.260	367.887	435.281	344.136
1775.1	682.838	688.852	680.208	540.222	548.091	371.132	438.626	347.329
1785.1	686.825	692.972	683.622	544.085	551.928	374.218	442.536	350.887
1795.1	691.072	696.738	687.434	547.659	555.787	377.722	445.569	353.816
1805.1	694.912	701.209	691.299	551.439	559.823	380.658	449.423	357.180
1815.1	698.701	705.018	695.261	555.394	563.321	384.253	452.916	360.481
1825.1	702.741	709.733	698.921	558.817	567.218	387.647	456.918	363.500
1835.1	707.051	713.848	702.738	562.382	570.335	390.284	459.588	366.778
1845.1	711.472	717.604	706.488	565.987	574.958	393.856	463.029	370.057
1855.1	715.184	722.213	710.595	569.704	578.222	396.932	466.488	373.977
1865.1	719.390	726.269	714.300	573.246	582.230	399.590	469.842	376.288

1875.1	723.422	731.374	719.384	676.930	599.801	402.973	473.171	379.657
1885.1	727.153	714.203	721.967	588.788	589.664	405.012	476.960	392.719
1895.1	731.131	736.554	726.104	584.261	593.174	408.440	480.194	355.526
1905.1	734.959	742.732	729.950	586.157	597.106	411.669	483.560	396.703
1915.1	738.734	746.632	733.807	591.641	600.965	414.581	486.832	391.979
1925.1	742.750	750.901	737.924	595.654	604.746	418.116	490.009	394.422
1935.1	746.734	755.024	741.950	599.009	608.250	420.558	493.424	399.162
1945.1	750.707	759.923	745.945	602.489	612.120	423.803	490.743	400.914
1955.1	754.377	764.292	750.039	909.869	615.754	426.842	500.244	403.621
1965.1	754.249	768.557	753.232	609.395	619.104	429.592	503.326	400.908
1975.1	762.217	772.651	757.274	913.221	623.252	432.964	506.997	406.691
1985.1	765.933	777.348	760.895	616.194	626.449	435.557	509.699	412.742
1995.1	769.400	781.379	764.555	619.970	630.145	418.148	513.368	416.006
2005.1	772.964	785.818	768.144	623.492	633.440	441.257	510.078	418.895
2015.1	779.426	790.301	771.913	927.368	636.963	444.313	520.090	422.272
2025.1	779.991	794.813	775.519	630.584	640.625	447.470	523.448	425.015
2035.1	783.552	798.848	778.706	433.900	643.866	450.109	526.450	427.757
2045.1	787.515	803.200	782.292	636.966	647.805	451.006	529.933	431.273
2055.1	791.225	807.033	785.820	940.382	651.293	456.005	532.957	433.960
2949.1	794.964	910.764	789.360	943.647	654.929	458.434	536.006	436.750
2075.1	798.545	814.645	792.594	947.316	658.440	461.534	539.459	439.746
2065.1	802.088	818.629	795.920	950.773	661.601	464.220	242.697	442.791
2095.1	805.696	822.454	799.459	954.093	665.134	467.421	545.906	445.704
2105.1	909.312	627.934	802.741	957.541	668.567	470.466	549.205	448.879
2115.1	812.717	829.960	806.221	660.351	671.998	473.146	551.942	451.457
2125.1	919.421	633.190	809.451	663.706	675.280	476.397	555.135	453.902
2135.1	819.824	636.516	812.880	667.115	670.957	476.766	558.379	457.092
2145.1	823.476	636.946	816.308	670.721	682.336	481.757	561.722	460.215
2155.1	826.978	843.828	819.487	673.675	685.914	484.383	564.507	462.995
2195.1	639.279	647.147	822.913	677.076	688.660	480.855	567.645	466.391
2175.1	833.878	851.019	826.389	680.030	692.702	490.407	571.066	468.660
2185.1	836.926	954.245	830.062	684.032	690.067	492.825	574.171	471.894
2195.1	845.326	857.669	833.239	686.682	699.609	495.054	577.104	474.772
2295.1	643.984	940.273	636.364	669.681	702.663	490.584	580.440	477.290
2215.1	847.172	865.366	639.935	693.330	705.955	500.846	583.320	480.474
2225.1	650.716	667.341	643.497	696.302	709.400	503.929	586.250	482.938
2235.1	853.765	871.036	846.829	699.823	712.546	506.189	589.279	485.915
2045.1	657.509	674.184	850.002	702.719	715.963	509.004	592.297	489.147
2255.1	860.555	877.703	853.571	706.189	719.281	511.425	595.789	491.814
2265.1**	603.766	666.925	856.445	709.150	722.449	514.047	596.463	464.074
2275.1	867.743	884.591	860.013	711.952	725.963	517.273	601.186	496.888
2065.1	670.137	667.465	863.103	715.742	706.930	516.640	604.014	500.371
2295.1	873.379	890.734	866.453	718.734	732.196	522.707	607.587	502.963
2095.1	679.621	894.053	669.969	721.625	735.606	525.116	610.506	505.760
2315.1	879.814	896.876	872.890	724.715	738.476	527.729	613.170	508.518
0325.1	603.154	900.666	876.455	727.560	741.837	530.596	616.140	510.619
2335.1	885.897	903.809	879.072	731.092	744.653	533.104	619.168	514.089
2345.1	669.405	906.579	603.007	734.009	740.062	535.450	600.337	510.536
2355.1	892.077	910.693	886.204	737.419	751.173	538.118	625.284	519.554
0365.1	695.316	614.060	906.975	740.351	754.165	546.680	628.026	520.001
2375.1	898.784	918.825	892.537	743.287	757.492	543.841	630.839	524.819
0365.1	601.345	919.544	695.554	746.546	760.452	546.145	633.099	507.602
2395.1	904.931	922.759	898.916	749.704	763.759	549.211	636.763	530.684
0405.1	902.670	606.001	991.962	750.339	796.766	551.407	639.375	533.060
2415.1	910.888	928.941	904.899	755.370	769.362	553.709	642.237	535.887
2405.1	914.443	930.109	906.656	756.004	772.436	556.070	645.046	560.309
2435.1	917.032	935.616	911.967	761.484	775.101	559.084	648.109	541.391
0445.1	920.467	636.536	915.400	764.660	776.600	592.074	651.110	544.143
2455.1	923.498	942.191	918.301	767.693	781.729	564.922	653.876	546.689
2465.1	606.409	645.156	901.405	770.503	264.657	567.120	656.564	646.287
2475.1	929.972	949.060	924.813	773.601	787.959	569.168	690.196	991.031
0486.1	932.650	651.650	927.727	776.160	790.266	571.604	660.197	554.509
2495.1	936.348	955.336	930.987	780.092	793.991	574.510	665.102	557.630
2505.1	939.126	958.043	634.069	780.830	796.001	576.496	667.656	559.510
2515.1	942.350	961.959	936.813	785.489	800.167	578.634	670.710	562.962
2525.1	645.941	964.919	940.121	788.888	803.116	581.735	673.413	565.458

2535.1	948.476	967.833	942.757	791.210	908.365	593.673	676.465	587.646
2545.1	951.737	971.141	945.945	799.027	909.414	586.247	679.287	590.792
2555.1	954.889	974.690	948.709	797.505	912.315	588.581	681.867	593.330
2565.1	957.823	978.004	958.881	800.973	915.044	591.047	684.567	596.274
2575.1	961.053	981.411	954.660	805.900	918.263	593.438	687.217	598.557
2585.1	963.836	984.274	958.824	806.422	921.015	595.824	690.185	581.245
2595.1	967.265	987.927	963.955	809.244	923.914	596.263	693.013	583.426
2605.1	970.248	991.839	968.591	812.660	926.812	600.548	696.035	586.721
2615.1	972.930	993.497	973.421	815.432	929.955	602.830	698.056	589.458
2625.1	976.189	997.493	978.752	818.154	932.410	605.726	701.492	591.979
2635.1	978.891	1000.664	983.829	821.024	935.307	607.401	704.147	594.473
2645.1	981.922	1004.864	988.889	823.794	938.480	609.279	706.967	597.055
2655.1	985.101	1006.920	993.143	826.886	941.099	611.713	709.765	599.384
2665.1	987.733	1010.578	997.925	829.982	944.387	613.844	712.528	602.015
2675.1	990.862	1013.734	1002.853	832.644	947.453	616.277	715.371	604.494
2685.1	993.792	1016.940	1007.149	835.810	950.178	618.254	718.481	607.276
2695.1	996.871	1020.669	1011.968	838.726	953.707	621.295	720.953	609.884
2705.1	1000.297	1023.895	1015.781	841.891	956.484	623.220	724.092	612.433
2715.1	1003.524	1027.643	1020.047	844.654	959.762	625.499	726.682	615.010
2725.1	1006.503	1031.142	1024.185	847.669	963.322	628.335	729.521	617.536
2735.1	1009.829	1034.745	1028.027	850.838	966.110	630.963	732.459	620.263
2745.1	1013.006	1038.140	1031.672	854.040	969.438	633.144	735.445	622.788
2755.1	1016.232	1041.609	1036.006	857.200	972.049	635.826	738.382	625.161
2765.1	1019.812	1045.445	1039.805	860.319	975.105	638.304	741.367	628.349
2775.1	1022.466	1048.947	1042.999	863.124	979.190	640.793	744.303	630.711
2785.1	1025.682	1052.299	1046.101	866.430	982.178	643.007	746.997	633.284
2795.1	1028.739	1055.953	1050.040	860.341	985.605	646.192	750.219	636.410
2805.1	1032.014	1059.252	1053.290	872.693	988.444	648.314	752.853	638.930
2815.1	1034.643	1061.962	1056.146	875.893	991.724	650.730	756.133	641.851
2825.1	1038.018	1065.462	1059.543	878.916	994.685	653.820	758.766	644.171
2835.1	1041.045	1068.322	1062.300	881.822	997.645	655.668	761.847	646.840
2845.1	1044.072	1071.674	1065.648	885.123	901.266	658.617	764.828	649.408
2855.1	1047.296	1075.026	1068.750	887.883	903.859	661.291	767.557	652.277
2865.1	1050.174	1077.836	1071.655	891.156	907.202	663.713	770.485	655.096
2875.1	1053.200	1081.188	1074.855	893.899	910.217	666.185	773.314	657.209
2885.1	1056.326	1084.491	1077.809	897.197	913.297	668.858	776.341	660.479
2895.1	1059.253	1088.174	1080.612	900.184	916.940	671.438	779.536	663.094
2905.1	1061.931	1094.547	1083.864	902.912	910.287	673.848	781.996	665.256
2915.1	1065.205	1059.476	1086.818	906.113	922.879	676.822	785.128	668.322
2925.1	1069.426	1104.553	1090.165	909.216	926.276	679.593	787.787	670.883
2935.1	1072.324	1109.089	1093.021	911.973	929.477	681.306	790.523	673.547
2945.1	1075.479	1113.821	1096.319	915.321	933.288	683.774	793.447	676.058
2955.1	3079.295	1317.962	1099.568	918.324	936.879	686.895	796.668	678.820
2965.1	1093.013	1122.276	1102.574	921.425	940.762	689.351	799.392	681.651
2975.1	1087.328	1126.294	1105.771	924.575	944.230	691.828	802.515	684.090
2495.1	1091.296	1330.632	1106.577	927.872	947.575	694.295	805.236	687.088
2995.1	1095.661	1134.251	1112.073	931.266	951.262	696.908	808.188	689.858
3005.1	1099.629	1138.127	1115.519	934.621	954.875	699.272	811.572	692.667
3015.1	3105.895	3142.822	1118.375	936.055	958.170	702.158	814.346	689.074
3025.1	1108.797	1146.266	1121.429	941.558	961.895	704.802	817.463	697.488
3035.1	1114.312	1149.819	1124.573	945.182	965.223	707.114	820.380	700.988
3045.1	1120.413	1154.054	1128.271	948.136	968.932	709.827	823.397	703.882
3055.1	1125.049	1157.753	1131.422	952.188	972.152	712.539	826.961	706.647
3065.1	1131.170	1161.259	1134.573	955.883	975.763	714.648	829.928	709.101
3075.1	1136.848	1164.929	1137.725	959.541	979.276	717.611	832.494	711.454
3085.1	1140.387	1168.752	1140.827	965.926	982.374	720.121	835.829	714.157
3095.1	1145.318	1172.483	1144.176	967.583	986.008	722.588	838.893	717.059
3105.1	1149.669	1176.941	1146.684	971.286	988.126	725.850	842.873	719.711
3115.1	1155.156	3188.319	1149.851	974.932	992.868	727.998	845.836	722.361
3125.1	1157.628	3187.809	1152.695	978.655	986.386	730.456	848.658	725.112
3135.1	1160.858	1193.472	1155.992	982.143	1000.102	732.311	852.185	727.963
3145.1	1164.225	1198.259	1159.985	985.974	3004.893	735.869	855.169	730.866
3155.1	1167.798	1202.702	1164.123	989.314	1007.878	737.925	858.621	733.758
3165.1	1170.975	1206.703	1168.592	992.899	1013.592	740.203	861.778	736.256
3175.1	1174.549	1211.821	1173.926	996.981	1019.184	743.337	864.912	738.883
3185.1	1177.726	1215.391	1178.093	1000.110	1018.998	745.691	868.398	742.824

1185.1	1181.549	1228.633	1184.664	1003.495	1021.013	748.696	871.596	744.595
1205.1	1195.102	1024.479	1199.933	1007.204	1036.474	751.200	674.001	747.590
1215.1	1188.897	1228.776	1196.496	1018.426	1038.285	753.953	878.855	750.434
1225.1	1193.416	1332.272	1202.163	1014.131	1034.417	757.106	890.964	752.279
1235.1	1197.939	1237.423	1207.548	1017.822	1038.364	759.587	884.424	756.171
1345.1	1707.753	1042.819	1212.372	1031.763	1042.387	762.559	887.716	758.663
1255.1	1287.274	1246.917	1217.581	1025.886	1046.298	765.288	891.219	761.855
1265.1	1211.292	1050.621	1221.743	1039.868	1050.448	768.360	894.569	765.095
1275.1	1215.828	1254.972	1229.985	1033.884	1054.345	771.818	898.456	767.836
1085.1	1319.646	1256.661	1229.685	1037.769	1050.097	773.989	901.657	771.024
1295.1	1223.373	1263.231	1233.781	1041.685	1062.262	777.847	884.957	774.013
1305.1	1307.852	1267.330	1237.383	1049.859	1065.091	779.205	988.649	776.882
1315.1	1228.488	1271.384	1241.836	1045.192	1069.594	783.453	911.652	779.930
1325.1	1731.912	1275.749	1244.639	1052.675	1073.637	785.548	915.491	783.776
1335.1	1237.492	1279.758	1248.391	1056.844	1077.315	788.345	918.740	786.108
1345.1	1240.774	1083.578	1251.799	1059.788	1080.944	791.739	921.913	788.847
1355.1	1743.788	1287.931	1255.582	1063.834	1084.646	794.484	925.383	791.783
1365.1	1247.148	1291.845	1258.613	1066.483	1089.399	797.328	928.161	794.766
1375.1	1258.224	1294.414	1262.288	1070.615	1091.789	800.371	931.678	797.799
1385.1	1253.359	1098.088	1265.282	1073.933	1095.316	803.015	934.788	800.931
1395.1	1256.842	1388.984	1268.345	1076.612	1098.723	806.586	938.218	803.764
1405.1	1259.438	1304.472	1271.310	1080.143	1101.962	808.999	941.022	806.796
1415.1	1763.813	1307.247	1274.324	1082.841	1105.348	811.848	944.218	809.827
1425.1	1265.888	1310.321	1277.141	1086.333	1108.709	815.205	947.366	812.757
1435.1	1268.837	1313.144	1279.958	1089.315	1111.632	817.771	950.411	815.489
1445.1	1272.523	1316.078	1282.826	1090.356	1114.444	820.860	953.459	818.518
1455.1	1274.742	1319.543	1285.595	1095.748	1118.052	823.789	956.487	821.398
1465.1	1277.899	1320.120	1288.661	1098.634	1121.131	826.239	959.058	824.336
1475.1	1280.937	1325.495	1291.357	1101.593	1124.308	828.978	962.304	826.510
1485.1	1283.179	1220.532	1294.646	1104.423	1137.220	831.967	965.194	829.835
1495.1	1286.487	1331.358	1297.911	1107.561	1130.338	834.504	968.445	832.663
1505.1	1288.850	1334.088	1300.405	1110.388	1133.261	837.142	971.147	835.242
1515.1	1291.548	1337.869	1303.651	1113.226	1136.333	839.829	974.045	838.317
1525.1	1294.440	1339.839	1306.423	1115.997	1139.254	842.913	976.942	840.540
1535.1	1297.538	1342.868	1309.294	1119.088	1141.983	845.188	979.742	843.930
1545.1	1300.621	1345.301	1312.413	1131.989	1145.053	848.385	982.402	846.101
1555.1	1303.712	1348.833	1315.827	1124.981	1147.781	850.870	985.487	848.778
1565.1	1306.505	1351.014	1318.395	1127.778	1150.882	853.606	988.385	851.881
1575.1	1309.597	1353.697	1321.079	1130.125	1153.434	856.291	990.819	854.888
1585.1	1313.891	1056.430	1323.695	1130.313	1156.817	858.627	993.337	858.706
1595.1	1314.885	1359.918	1326.876	1135.864	1159.233	861.518	996.337	859.381
1605.1	1317.779	1062.570	1329.760	1138.560	1161.719	864.144	999.194	861.987
1615.1	1320.623	1365.454	1332.277	1141.564	1164.936	866.429	1001.883	864.532
1625.1	1303.869	1369.910	1335.797	1144.376	1167.910	869.410	1004.534	867.295
1635.1	1326.210	1371.397	1338.177	1147.099	1170.598	871.695	1007.389	870.126
1645.1	1330.718	1074.930	1341.29.	1150.141	1173.929	874.437	1009.883	873.304
1655.1	1330.957	1377.816	1344.078	1152.595	1176.874	877.889	1012.631	874.977
1665.1	1333.953	1381.002	1347.884	1155.195	1170.975	870.641	1015.488	877.600
1675.1	1336.758	1384.138	1350.279	1158.483	1182.846	882.123	1018.829	880.874
1685.1	1339.398	1080.429	1352.859	1160.789	1184.588	884.586	1020.875	880.042
1695.1	1342.598	1390.114	1355.936	1163.587	1187.776	887.484	1023.279	885.269
1705.1	1345.194	1392.955	1358.865	1166.521	1190.360	889.868	1006.184	887.701
1715.1	1347.643	1395.295	1361.645	1169.182	1193.213	892.695	1028.675	890.668
1725.1	1350.798	1298.694	1364.306	1171.587	1196.200	895.106	1021.177	893.005
1735.1	1353.192	1401.475	1367.287	1174.284	1198.929	897.118	1033.879	895.258
1745.1	1356.342	1404.417	1360.980	1170.910	1201.303	800.888	1006.406	898.076
1755.1	1359.218	1407.459	1373.116	1180.128	1204.334	902.319	1039.418	900.844
2765.1	1361.444	1409.753	1375.603	1182.980	1207.115	904.997	1041.001	900.110
1775.1	1364.396	1412.397	1378.287	1185.111	1209.871	907.228	1043.988	905.836
1785.1	1267.749	1415.141	1381.100	1188.007	1210.480	910.184	1247.200	908.027
1795.1	1370.792	1417.988	1383.895	1190.881	1215.287	912.516	1049.787	910.629
1805.1	1373.906	1400.807	1086.242	1100.679	1017.074	914.913	1002.200	930.097
1815.1	1376.918	1422.578	1388.728	1196.919	1220.895	917.211	1099.819	919.710
1825.1	1379.815	1405.074	1391.763	1198.904	1003.071	910.040	1057.910	910.130
1835.1	1382.778	1427.971	1394.251	1201.248	1225.894	921.501	1099.878	926.468
1845.1	1385.329	1430.819	1397.137	1204.738	1228.782	924.878	1003.888	923.324

3895.1	1387.738	1433.867	1388.774	1207.614	1235.175	926.852	1042.184	822.544
3845.1	1199.737	1417.815	1481.969	1299.544	1233.989	929.195	1097.471	929.089
3879.1	1383.643	1441.865	1464.921	1212.462	1236.643	837.107	1076.312	930.562
3869.1	1195.749	1445.815	1487.642	1214.899	1239.231	934.339	1072.914	933.347
3805.1	1386.488	1448.917	1410.531	1217.700	1242.794	936.613	1075.592	935.968
3885.1	1408.865	1421.866	1413.421	1220.883	1245.843	939.141	1077.886	937.937
3915.1	1403.121	1454.722	1418.812	1222.595	1248.072	941.719	1080.393	940.583
3925.1	1408.833	1457.275	1416.784	1224.899	1250.979	943.944	1082.819	942.872
3935.1	1410.441	1459.729	1421.949	1227.971	1253.250	946.222	1085.442	945.438
3845.1	1413.638	1462.931	1424.288	1230.626	1256.158	949.893	1089.489	948.281
3955.1	1413.189	1494.738	1424.532	1233.884	1258.821	951.271	1090.713	950.273
3965.1	1415.569	1466.917	1429.229	1235.448	1261.362	953.498	1093.214	952.838
3975.1	1417.938	1469.599	1431.928	1238.000	1263.688	959.328	1095.764	955.354
3985.1	1420.441	1472.255	1434.615	1240.385	1266.544	958.201	1098.689	957.721
3995.1	1423.154	1474.711	1437.909	1243.410	1298.964	960.873	1100.422	988.339
4005.1	1425.105	1477.470	1440.268	1248.828	1271.382	963.158	1103.217	962.858
4015.1	1428.828	1490.229	1442.783	1247.885	1274.122	965.924	1105.473	995.119
4025.1	1430.581	1482.887	1445.552	1250.738	1276.616	968.248	1107.826	967.485
4035.1	1433.185	1484.945	1448.096	1252.952	1278.915	970.522	1110.621	999.852
4045.1	1435.910	1487.758	1450.686	1255.363	1282.046	973.099	1112.926	972.169
4055.1	1434.134	1490.241	1453.145	1257.921	1784.091	975.567	1115.182	974.468
4065.1	1440.398	1492.224	1455.494	1260.486	1288.599	977.645	1117.928	977.148
4075.1	1442.913	1495.841	1457.694	1292.946	1289.292	980.217	1120.837	979.366
4085.1	1445.228	1498.709	1488.599	1265.402	1291.782	982.294	1122.538	981.838
4095.1	1448.198	1501.971	1463.746	1267.785	1294.181	984.915	1125.088	983.958
4105.1	1450.484	1504.738	1467.848	1270.226	1297.117	987.141	1127.638	986.562
4115.1	1453.384	1507.158	1470.151	1272.569	1299.712	989.811	1129.948	988.881
4125.1	1455.953	1510.470	1473.385	1275.199	1301.964	992.139	1131.953	990.947
4135.1	1458.472	1513.035	1476.160	1277.489	1304.755	994.112	1134.691	993.859
4145.1	1461.445	1515.099	1479.369	1280.000	1307.449	997.075	1137.201	995.924
4155.1	1463.984	1517.716	1481.921	1282.882	1309.702	999.353	1139.555	998.098
4165.1	1466.334	1520.485	1484.376	1285.148	1312.494	1001.520	1141.959	1000.506
4175.1	1468.855	1523.003	1487.883	1287.217	1314.993	1004.247	1143.981	1002.723
4185.1	1471.427	1525.421	1489.289	1290.272	1317.149	1006.921	1146.373	1005.184
4195.1	1473.899	1528.394	1491.997	1292.785	1320.138	1008.948	1149.218	1007.501
4205.1	1476.119	1530.460	1494.659	1295.827	1322.540	1011.364	1151.973	1009.983
4215.1	1478.087	1532.980	1496.913	1297.615	1324.844	1013.788	1153.987	1012.377
4225.1	1481.578	1535.552	1499.572	1300.178	1327.487	1016.356	1156.478	1014.947
4235.1	1482.943	1538.124	1502.182	1302.449	1330.019	1018.388	1158.833	1017.203
4245.1	1487.884	1540.344	1504.894	1305.858	1332.517	1021.058	1161.139	1019.184
4255.1	1488.347	1543.826	1506.953	1307.550	1334.553	1023.323	1163.494	1021.192
4265.1	1492.177	1545.998	1509.313	1309.892	1337.692	1025.309	1165.947	1023.784
4275.1	1494.056	1548.722	1511.729	1312.334	1339.882	1028.168	1168.286	1380.018
4285.1	1497.332	1551.854	1513.635	1315.170	1342.883	1020.944	1170.950	1088.185
4295.1	1499.018	1554.177	1516.348	1317.361	1345.052	1032.859	1173.013	1030.896
4305.1	1502.237	1556.953	1519. 94	1319.987	1347.318	1035.888	1175.487	1033.108
4315.1	1504.665	1559.332	1521.276	1322.227	1349.568	1037.888	1177.381	1035.829
4325.1	1507.044	1562.467	1524.092	1324.373	1352.170	1039.924	1179.883	1038.949
4335.1	1509.371	1564.945	1526.789	1326.702	1354.625	1042.048	1182.681	1039.884
4345.1	1512.884	1597.778	1528.973	1329.458	1357.277	1044.019	1184.844	1042.019
4355.1	1514.434	1570.207	1531.286	1331.658	1359.635	1047.239	1187.899	1044.838
4365.1	1519.814	1572.584	1533.858	1333.853	1302.238	1049.200	1189.851	1046.352
4375.1	1519.448	1575.826	1536.576	1336.419	1364.302	1051.778	1191.644	1049.188
4385.1	1522.032	1578.109	1538.948	1338.970	1306.790	1054.002	1193.971	1051.126
4395.1	1524.878	1580.436	1541.089	1341.089	1369.602	1056.571	1196.486	1053.899
4405.1	1527.405	1582.919	1543.979	1343.998	1371.871	1058.991	1198.783	1055.883
4415.1	1529.898	1585.352	1545.345	1346.179	1374.288	1061.362	1201.189	1058.887
4425.1	1532.028	1587.735	1548.298	1348.582	1379.788	1093.831	1203.251	1060.885
4435.1	1534.867	1589.814	1550.988	1351.978	1378.902	1065.955	1205.992	1062.894
4445.1	1537.246	1592.401	1553.880	1353.838	1381.165	1068.523	1207.789	1064.882
4455.1	1539.276	1594.789	1555.583	1355.988	1383.772	1070.896	1210.224	1066.688
4465.1	1541.387	1597.993	1558.358	1357.958	1386.035	1072.820	1212.789	1069.852
4475.1	1543.694	1598.848	1561.885	1360.344	1388.398	1075.931	1214.948	1071.396
4485.1	1545.378	1600.877	1563.458	1362.898	1390.589	1077.888	1217.883	1073.971
4495.1	1549.044	1602.276	1566.169	1364.623	1393.183	1080.326	1219.588	1075.887
4505.1	1548.728	1604.939	1568.783	1398.877	1394.969	1082.897	1821.878	1077.883

4515.1	1557.302	1509.170	1571.766	1369.225	[illegible]	1084.915	1223.038	1080.608
4525.1	1557.118	1415.998	1570.245	1371.056	[illegible]	1087.956	1226.092	1082.626
4535.1	1561.688	1417.781	1479.685	1373.383	[illegible]	1089.561	1226.451	1084.946
4545.1	1565.555	1419.533	1483.524	1376.453	[illegible]	1092.327	1230.859	1087.007
4555.1	1568.191	1419.889	1484.746	1379.077	[illegible]	1094.302	1232.972	1089.221
4565.1	1568.915	1416.261	1584.999	1381.603	[illegible]	1096.722	1235.479	1091.485
4575.1	1567.805	1415.187	1582.975	1384.278	[illegible]	1099.784	1237.691	1093.154
4585.1	1569.097	1418.562	1578.218	1386.961	[illegible]	1101.562	1239.992	1095.013
4595.1	1567.844	1405.499	1574.121	1387.697	[illegible]	1104.080	1242.312	1098.080
4605.1	1557.618	1399.912	1569.921	1388.489	[illegible]	1106.402	1244.377	1100.147
4615.1	1553.093	1393.923	1566.827	1388.787	[illegible]	1108.673	1246.196	1102.589
4625.1	1548.214	1568.140	1560.277	1389.035	[illegible]	1110.797	1247.671	1104.429
4635.1	1543.744	1382.311	1555.631	1384.911	[illegible]	1112.624	1249.147	1106.693
4645.1	1539.124	1376.637	1551.244	1380.465	[illegible]	1115.390	1250.474	1108.388
4655.1	1534.383	1570.359	1546.654	1387.647	[illegible]	1117.168	1251.695	1110.162
4665.1	1529.738	1563.883	1539.296	1384.507	[illegible]	1116.650	1252.245	1112.294
4675.1	1524.566	1557.437	1531.702	1385.219	[illegible]	1120.578	1252.888	1113.484
4685.1	1519.843	1550.440	1524.787	1383.485	[illegible]	1121.761	1253.229	1115.100
4695.1	1515.472	1543.321	1517.907	1381.683	[illegible]	1123.638	1253.229	1116.241
4705.1	1504.993	1536.258	1511.072	1379.822	[illegible]	1124.626	1253.229	1117.520
4715.1	1501.125	1528.996	1504.291	1377.542	[illegible]	1125.663	1252.933	1116.940
4725.1	1495.058	1521.996	1497.666	1374.967	[illegible]	1126.700	1252.940	1118.784
4735.1	1488.943	1514.696	1491.345	1372.442	[illegible]	1127.441	1252.245	1120.670
4745.1	1483.135	1507.904	1485.328	1369.918	[illegible]	1128.379	1251.458	1121.310
4755.1	1477.179	1501.117	1479.315	1364.751	[illegible]	1129.120	1250.573	1121.784
4765.1	1471.327	1494.434	1473.195	1363.960	[illegible]	1129.565	1249.343	1122.249
4775.1	1465.838	1488.157	1467.640	[illegible]	[illegible]	1130.207	1248.163	1122.491
4785.1	1460.135	1481.633	1461.645	[illegible]	[illegible]	1130.405	1247.130	1122.787
4795.1	1455.846	1475.564	1456.504	[illegible]	[illegible]	1130.845	1245.950	1122.984
4805.1	1449.557	1469.998	1450.846	[illegible]	[illegible]	1130.750	1244.872	1123.033
4815.1	1444.722	1463.886	1445.650	[illegible]	[illegible]	1130.948	1243.492	1123.131
4825.1	1439.148	1458.026	1440.695	[illegible]	[illegible]	1131.195	1241.673	1122.838
4835.1	1433.988	1452.220	1435.314	[illegible]	[illegible]	1130.849	1240.247	1122.885
4845.1	1429.234	1446.916	1430.623	[illegible]	[illegible]	1130.948	1238.578	1122.590
4855.1	1424.289	1441.585	1425.535	[illegible]	[illegible]	1130.802	1236.984	1122.245
4865.1	1419.286	1435.966	1420.698	[illegible]	[illegible]	1130.298	1235.331	1122.048
4875.1	1414.485	1430.969	1416.112	[illegible]	[illegible]	1129.988	1233.267	1121.433
4885.1	1409.945	1425.774	1411.129	[illegible]	[illegible]	1129.219	1231.743	1121.212
4895.1	1405.578	1420.831	1406.845	[illegible]	[illegible]	1129.170	1230.872	1120.923
4905.1	1400.113	1415.740	1402.015	[illegible]	[illegible]	1128.379	1228.303	1119.881
4915.1	1395.499	1410.801	1397.485	[illegible]	[illegible]	1127.935	1226.387	1119.486
4925.1	1391.038	1405.713	1392.957	[illegible]	[illegible]	1127.589	1224.323	1118.288
4935.1	1386.227	1400.777	1388.530	[illegible]	[illegible]	1126.801	1222.653	1117.819
4945.1	1382.018	1395.893	1384.203	[illegible]	[illegible]	1126.157	1220.788	1118.979
4955.1	1377.318	1391.258	1379.530	[illegible]	[illegible]	1125.416	1218.579	1116.191
4965.1	1372.804	1386.254	1375.255	[illegible]	[illegible]	1124.873	1216.512	1115.601
4975.1	1368.499	1381.947	1370.783	[illegible]	[illegible]	1124.181	1214.547	1114.370
4985.1	1363.746	1377.119	1366.760	[illegible]	[illegible]	1123.292	1212.988	1113.077
4995.1	1359.894	1372.942	1362.489	[illegible]	[illegible]	1122.798	1210.718	1112.795
5005.1	1355.042	1368.164	1358.269	[illegible]	[illegible]	1121.564	1208.908	1111.888
5015.1	1351.842	1363.390	1354.000	[illegible]	[illegible]	1120.576	1206.839	1110.974
5025.1	1346.844	1359.114	1350.179	[illegible]	[illegible]	1119.884	1204.977	1110.488
5035.1	1342.966	1354.942	1345.814	[illegible]	[illegible]	1118.748	1202.318	1109.889
5045.1	1338.399	1350.318	1342.044	[illegible]	[illegible]	1118.100	1200.305	1107.976
5055.1	1334.203	1345.947	1338.029	[illegible]	[illegible]	1117.168	1198.439	1106.693
5065.1	1330.058	1341.775	1334.012	[illegible]	[illegible]	1116.081	1196.479	1105.788
5075.1	1326.164	1337.805	1330.249	[illegible]	[illegible]	1115.439	1193.971	1104.478
5085.1	1321.821	1333.286	1326.331	[illegible]	[illegible]	1113.908	1192.186	1103.543
5095.1	1318.128	1329.217	1322.387	[illegible]	[illegible]	1112.871	1190.893	1101.820
5105.1	1313.837	1325.074	1318.692	[illegible]	[illegible]	1111.884	1187.882	1100.688
5115.1	1310.046	1320.882	1314.941	[illegible]	[illegible]	1110.698	1185.898	1099.686
5125.1	1306.006	1317.014	1311.078	[illegible]	[illegible]	1109.957	1183.919	1098.375
5135.1	1302.142	1313.007	1307.116	[illegible]	[illegible]	1108.673	1181.698	1097.243
5145.1	1298.178	1309.032	1303.701	[illegible]	[illegible]	1107.933	1179.968	1095.884
5155.1	1294.498	1305.067	1299.791	[illegible]	[illegible]	1106.896	1177.282	1094.389
5165.1	1290.583	1300.954	1296.276	[illegible]	[illegible]	1105.218	1175.281	1093.150

5135.1	1206.915	1207.387	1202.984	1240.115	1241.527	1104.159	1177.915	1091.788
5145.1	1203.629	1203.414	1209.007	1237.312	1238.295	1102.646	1170.629	1090.645
5155.1	1199.787	1198.884	1206.684	1234.485	1235.764	1101.858	1168.605	1089.507
5165.1	1195.758	1194.144	1202.035	1231.511	1232.346	1100.722	1166.761	1088.237
5175.1	1191.122	1189.312	1198.723	1229.054	1229.661	1099.436	1164.622	1086.761
5185.1	1188.817	1187.805	1196.201	1226.298	1226.935	1098.401	1162.169	1085.196
5195.1	1189.191	1189.215	1197.351	1226.294	1227.411	1098.870	1160.554	1084.103
5205.1	1191.997	1191.819	1200.641	1229.648	1229.066	1099.932	1158.744	1082.676
5215.1	1190.285	1188.979	1199.438	1227.774	1227.947	1098.549	1155.988	1081.445
5225.1	1187.288	1185.725	1202.021	1225.896	1225.116	1097.304	1153.780	1080.204
5235.1	1191.117	1191.302	1198.813	1212.442	1212.457	1092.179	1151.720	1078.384
5245.1	1188.334	1187.848	1195.748	1209.046	1209.432	1090.747	1149.905	1077.311
5255.1	1189.090	1184.435	1192.539	1207.088	1206.822	1089.512	1147.550	1075.667
5265.1	1191.119	1191.263	1189.527	1204.435	1203.944	1088.277	1145.539	1074.407
5275.1	1188.884	1188.149	1186.269	1201.734	1201.261	1087.067	1143.479	1073.079
5285.1	1185.484	1184.868	1183.356	1199.130	1198.269	1086.055	1141.321	1071.307
5295.1	1182.371	1181.574	1180.394	1196.626	1195.847	1084.475	1139.310	1070.076
5305.1	1179.438	1178.513	1177.289	1194.023	1193.359	1083.438	1137.152	1068.551
5315.1	1176.287	1175.397	1174.324	1191.371	1190.531	1081.610	1135.288	1067.271
5325.1	1173.373	1172.482	1171.363	1188.888	1188.288	1080.475	1133.278	1066.140
5335.1	1170.242	1169.196	1168.265	1186.265	1185.313	1079.487	1130.997	1064.465
5345.1	1167.284	1166.188	1165.449	1183.761	1182.729	1078.153	1129.296	1063.048
5355.1	1164.427	1163.244	1162.677	1181.527	1180.584	1076.968	1127.196	1061.414
5365.1	1161.597	1160.231	1160.016	1178.950	1177.561	1075.684	1125.186	1060.036
5375.1	1158.715	1157.268	1157.304	1176.299	1174.249	1074.104	1122.930	1058.805
5385.1	1155.982	1154.592	1154.492	1174.044	1172.881	1072.869	1120.988	1057.279
5395.1	1152.982	1151.341	1151.534	1171.587	1170.151	1071.387	1119.301	1056.147
5405.1	1150.443	1148.774	1149.167	1169.329	1167.909	1070.540	1117.430	1054.324
5415.1	1147.459	1145.913	1146.258	1166.924	1165.423	1069.118	1115.182	1052.898
5425.1	1144.207	1142.659	1143.546	1164.614	1163.035	1068.029	1113.318	1051.818
5435.1	1141.175	1140.078	1141.130	1162.114	1160.646	1066.844	1111.308	1050.240
5445.1	1138.245	1137.272	1138.271	1159.783	1158.210	1064.918	1109.494	1048.961
5455.1	1136.712	1134.903	1135.806	1157.649	1156.187	1064.078	1107.434	1047.385
5465.1	1134.180	1132.346	1133.243	1155.293	1153.280	1062.744	1105.922	1045.859
5475.1	1131.499	1129.480	1130.483	1152.987	1151.290	1061.559	1103.808	1044.579
5485.1	1129.468	1126.904	1128.068	1150.677	1149.146	1060.522	1101.893	1043.152
5495.1	1126.586	1124.244	1125.604	1148.714	1146.987	1058.744	1099.883	1042.019
5505.1	1124.003	1121.538	1123.190	1146.216	1144.468	1057.707	1098.089	1040.492
5515.1	1121.173	1119.013	1120.381	1144.057	1142.178	1056.225	1096.194	1038.819
5525.1	1118.791	1116.497	1118.301	1141.849	1139.888	1055.039	1094.440	1037.319
5535.1	1116.359	1113.932	1116.045	1139.642	1137.949	1054.200	1092.332	1035.161
5545.1	1113.679	1111.418	1113.286	1137.532	1135.259	1052.570	1090.684	1033.078
5555.1	1111.445	1109.097	1111.167	1135.570	1133.359	1051.831	1088.899	1033.661
5565.1	1109.282	1106.539	1108.892	1133.440	1130.728	1050.028	1087.232	1032.625
5575.1	1106.631	1103.770	1106.241	1131.057	1128.528	1048.717	1085.320	1030.896
5585.1	1104.349	1101.449	1104.073	1129.070	1126.782	1047.630	1083.102	1029.169
5595.1	1102.066	1098.887	1101.709	1126.985	1124.634	1046.099	1081.691	1028.088
5605.1	1099.833	1096.693	1099.443	1125.121	1122.397	1045.259	1079.975	1026.806
5615.1	1097.352	1094.375	1096.882	1122.693	1120.254	1043.876	1078.259	1025.427
5625.1	1095.119	1091.933	1094.813	1120.706	1118.378	1042.295	1076.248	1023.999
5635.1	1093.135	1089.917	1092.646	1118.891	1116.064	1041.387	1074.585	1022.423
5645.1	1090.459	1087.347	1089.987	1116.702	1113.994	1039.778	1073.110	1021.389
5655.1	1088.372	1084.951	1088.017	1114.526	1112.240	1038.887	1071.345	1019.813
5665.1	1086.898	1082.668	1085.949	1112.490	1110.024	1037.802	1069.334	1018.582
5675.1	1083.807	1080.345	1083.634	1110.700	1107.905	1036.418	1067.509	1017.499
5685.1	1081.024	1078.229	1081.320	1108.738	1106.005	1035.181	1065.652	1015.726
5695.1	1079.442	1075.661	1079.153	1106.462	1103.740	1033.699	1064.478	1014.944
5705.1	1077.457	1073.443	1077.282	1104.667	1102.084	1032.711	1062.881	1013.116
5715.1	1074.077	1071.478	1074.826	1102.883	1099.649	1031.377	1060.783	1011.934
5725.1	1072.704	1069.153	1072.653	1100.898	1097.895	1030.290	1059.134	1010.653
5735.1	1070.868	1066.885	1070.888	1098.732	1096.141	1029.253	1057.516	1009.323
5745.1	1068.578	1064.642	1068.659	1096.820	1094.193	1027.820	1056.045	1008.043
5755.1	1066.293	1062.495	1066.446	1095.258	1092.861	1026.486	1054.377	1006.466
5765.1	1064.411	1060.674	1064.381	1093.435	1090.128	1025.201	1052.415	1005.286
5775.1	1062.376	1058.709	1062.510	1091.179	1088.421	1024.114	1050.695	1004.182
5785.1	1060.443	1056.389	1060.442	1089.413	1086.594	1023.076	1049.375	1002.772

Table A-III

Temperature Data Print Out for Round 4955

Thermocouple No.	7	2	3	4	5	6	9	10
Multiplexer Channel	01	02	03	04	05	06	09	10

	Time (msec)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)
	735.1	79.538	79.630	79.847	79.896	79.613	79.781	79.692	79.516
	745.1	79.428	79.555	79.736	79.678	79.229	79.536	79.638	79.488
	755.1	79.538	79.610	79.847	79.841	79.667	79.811	79.583	79.516
	765.1	79.372	79.665	79.681	79.678	79.451	79.481	79.692	79.516
	775.1	79.538	79.446	79.847	79.787	79.694	79.756	79.583	79.571
	785.1	79.538	79.775	79.847	79.759	79.667	79.701	79.583	79.571
	795.1	79.483	79.720	79.681	79.787	79.559	79.536	79.747	79.708
	805.1	79.483	79.665	79.792	79.787	79.776	79.811	79.638	79.406
	815.1	79.428	79.555	79.626	79.732	79.451	79.591	79.638	79.571
	825.1	79.483	79.610	79.626	79.732	79.667	79.701	79.528	79.571
	835.1	79.483	79.665	79.736	79.841	79.559	79.756	79.692	79.351
	845.1	79.428	79.501	79.792	79.678	79.613	79.591	79.638	79.625
	855.1	79.538	79.665	79.847	79.732	79.559	79.921	79.528	79.351
	865.1	79.483	79.555	79.681	79.623	79.505	79.591	79.528	79.680
	875.1	79.648	79.665	79.736	79.732	79.721	79.646	79.383	79.516
	885.1	79.593	79.775	79.736	79.705	79.613	79.811	79.747	79.461
	895.1	79.483	79.555	79.736	79.732	79.613	79.426	79.747	79.625
	905.1	79.538	79.665	79.736	79.787	79.721	79.811	79.638	79.242
	915.1	79.372	79.665	79.736	79.623	79.505	79.481	79.692	79.680
	925.1	79.483	79.555	79.736	79.787	79.776	79.756	79.528	79.571
	935.1	79.593	79.830	79.681	79.678	79.613	79.701	79.692	79.516
	945.1	79.428	79.336	79.792	79.678	79.532	79.481	79.801	79.680
	955.1	79.538	79.775	79.792	79.732	79.694	79.756	79.583	79.297
	965.1	79.428	79.720	79.681	79.732	79.559	79.591	79.692	79.571
	975.1	79.483	79.501	79.736	79.623	79.667	79.646	79.583	79.571
	985.1	79.428	79.555	79.736	79.841	79.613	79.756	79.583	79.571
	995.1	79.538	79.555	79.792	79.732	79.559	79.591	79.638	79.680
	1005.1	79.593	79.610	79.736	79.678	79.667	79.866	79.528	79.351
Lpd Bloc	1015.1	79.372	79.610	79.571	79.678	79.396	79.426	79.583	79.461
	1025.1	79.593	79.501	79.792	79.787	79.667	79.591	79.583	79.516
	1035.1	79.593	86.136	89.467	92.577	79.884	79.756	79.528	79.461
	1045.1	79.538	115.562	128.083	136.428	82.077	81.798	80.918	79.790
	1055.1	80.281	149.411	170.685	180.860	89.461	89.808	84.930	79.023
	1065.1	81.250	189.394	202.335	218.779	101.232	101.156	92.135	79.625
	1075.1	84.396	222.797	228.984	250.546	114.595	119.813	108.779	88.447
	1085.1	88.148	246.988	254.551	278.347	127.864	131.029	110.838	88.447
	1095.1	93.859	277.110	287.708	312.824	140.899	145.681	121.784	92.288
	1105.1	99.661	317.948	331.766	359.888	157.995	163.666	134.175	83.624
	1115.1	106.885	368.991	375.111	413.771	177.435	184.418	149.073	86.698
	1125.1	115.211	408.21'	416.146	468.387	199.816	207.999	166.188	89.261
	1135.1	124.798	442.928	454.813	518.173	224.486	233.402	185.286	92.852
	1145.1	135.694	485.521	491.533	565.244	240.316	259.456	206.722	96.914
	1155.1	147.926	529.958	528.184	618.498	273.911	286.823	228.650	101.664
	1165.1	161.763	574.819	564.020	654.729	298.982	313.876	255.889	107.664
	1175.1	176.143	619.114	601.299	696.168	325.351	348.671	280.533	114.419
	1185.1	191.328	663.606	630.726	743.227	352.494	367.680	304.913	121.681
	1195.1	206.744	710.589	671.843	784.861	381.176	394.781	327.313	129.914
	1205.1	222.377	757.139	707.837	823.000	410.647	421.762	349.714	137.838

1215.1	238.198	891.370	744.442	886.565	447.356	446.847	371.834	147.420	
1225.1	284.885	823.667	781.423	920.176	472.231	475.667	394.132	157.263	
1235.1	271.647	858.314	815.842	969.846	501.194	502.752	417.136	167.626	
1245.1	286.815	868.448	850.434	1006.778	529.362	530.241	440.064	179.264	
1255.1	304.096	907.562	881.214	1045.952	557.035	558.657	461.845	190.229	
1265.1	321.481	948.346	917.485	1080.975	583.728	586.115	484.936	202.400	
1275.1	340.838	987.033	943.741	1115.437	610.697	614.300	507.955	214.401	
1285.1	358.549	1024.742	988.352	1151.594	636.693	642.369	530.097	226.474	
1295.1	376.115	1057.854	1028.772	1186.634	662.073	670.771	553.764	239.165	
1305.1	393.635	1090.389	1061.299	1216.166	687.697	699.520	576.567	251.934	
1315.1	411.159	1120.362	1094.231	1247.564	712.846	726.840	600.566	264.840	
1325.1	429.228	1147.777	1127.415	1276.077	738.295	753.547	623.495	276.024	
1335.1	447.078	1172.887	1160.304	1308.064	763.642	778.990	660.091	290.869	
1345.1	465.404	1195.584	1191.584	1336.910	788.940	804.104	693.797	304.426	
1355.1	483.120	1214.417	1221.101	1363.132	814.661	828.770	726.878	316.848	
1365.1	501.126	1237.339	1247.919	1387.287	839.554	851.310	757.522	330.611	
1375.1	519.190	1258.494	1271.928	1408.457	861.894	873.845	783.036	343.768	
1385.1	537.001	1275.409	1295.413	1429.720	885.639	895.264	806.324	356.696	
1395.1	554.967	1293.417	1317.284	1449.293	904.478	915.694	830.614	370.421	
1405.1	572.332	1310.269	1336.295	1467.428	924.936	936.255	853.960	383.759	
1415.1	588.283	1329.667	1357.382	1482.992	945.865	955.514	878.104	396.967	
1425.1	606.042	1341.225	1376.392	1499.529	966.292	974.469	901.558	410.408	
1435.1	622.494	1355.810	1394.621	1514.640	985.659	993.158	925.234	423.255	
1445.1	638.468	1370.121	1411.729	1530.424	1004.335	1011.447	946.184	436.336	
1455.1	654.400	1382.357	1427.849	1545.203	1023.417	1029.483	964.220	448.981	
1465.1	669.707	1455.318	1442.969	1559.074	1103.181	1046.671	980.134	464.026	
1475.1	684.892	1530.978	1457.495	1572.185	1357.904	1064.603	994.815	506.179	
1485.1	700.588	1603.824	1471.586	1584.078	1156.152	1082.579	1009.814	577.626	
1495.1	715.951	1601.663	1486.812	1595.179	1396.977	1101.146	1025.584	1512.888	
1505.1	732.534	89.201	1502.987	1606.699	1587.403	1118.332	1059.183	1802.452	
1515.1	750.650	-359.720	1520.146	1619.195	1964.804	1133.692	1073.453	2233.018	
1525.1	769.395	335.409	1537.334	1633.460	2207.182	1151.600	1084.829	2233.018	
1535.1	787.813	711.842	1554.501	1648.917	2207.182	1174.807	1098.688	2233.018	
1545.1	805.906	2121.526	1572.662	1662.309	2207.182	1193.137	1110.425	2233.018	
1555.1	823.877	1937.993	1586.688	1677.573	2207.182	1212.374	1122.538	2233.018	
1565.1	841.178	1768.986	1599.870	1690.995	2207.182	1229.395	1138.525	2119.315	
1575.1	857.863	2108.949	1612.382	1703.622	2207.182	1245.979	1155.694	1743.690	
1585.1	874.483	2218.385	1623.739	1716.475	2207.182	1262.326	1162.927	2181.824	
1595.1	891.436	2163.705	1641.378	1726.116	2207.182	1278.088	1216.021	1888.255	
1605.1	906.726	2128.524	1659.083	1735.641	1203.341	1293.217	1234.791	-2880.858	
1615.1	924.808	2044.622	1626.043	1746.157	-2812.025	1307.710	1246.245	-2880.692	
1625.1	940.063	1977.841	1581.720	1757.645	-2779.415	1321.868	1262. [illegible]	-733.359	
1635.1	974.780	2029.836	1532.866	1912.149	2154.842	1335.785	1343.587	2035.907	
1645.1	1041.263	1659.082	1433.501	2200.869	2207.182	1348.478	1438.475	2225.483	
1655.1	1261.632	1913.248	1332.687	1443.199	2207.182	1361.165	1739.669	2233.010	
1665.1	1663.322	1869.722	1257.694	-1293.179	2207.182	1372.774	2028.137	2233.010	
1675.1	1519.024	1581.066	1213.818	2226.166	2207.182	1384.840	2120.017	2233.018	
1685.1	-631.696	1884.551	1202.656	2226.188	2207.182	1487.918	2226.584	2233.010	
1695.1	-2045.598	2170.080	1372.512	2226.166	2207.182	1461.570	2226.584	2233.010	
1705.1	2252.384	2237.327	1458.265	2226.166	2207.182	1888.879	2226.584	2233.018	
1715.1	2252.384	2237.327	1527.330	2226.166	2207.182	2241.237	2226.584	2233.010	
1725.1	2252.384	2237.327	1536.681	2226.166	1396.982	2241.237	2226.584	2227.782	
1735.1	2252.384	2237.327	1997.134	2207.078	2156.510	2241.237	2226.584	2233.010	
1745.1	1894.635	2237.327	2141.243	1922.482	2207.182	2241.237	2226.584	2189.434	
1755.1	2252.384	2170.996	1628.512	1866.847	1963.187	1892.272	2226.584	2111.771	
1765.1	2252.384	2078.739	1608.092	2053.817	2142.882	1978.825	2226.584	1742.908	
1775.1	2252.384	2180.486	1037.815	2186.785	2202.509	2241.237	2226.584	1516.159	
1785.1	2252.384	2226.597	1603.754	2226.166	2207.182	2241.237	2226.584	1439.877	
1795.1	2252.384	2222.465	2146.867	2226.166	2207.182	2241.237	2226.584	1113.336	
1805.1	2255.426	2237.327	1535.031	2224.656	2196.631	2083.643	2226.584	992.865	
1815.1	-307.530	2237.327	1166.691	2085.489	2207.182	1473.412	2226.584	912.636	
1825.1	2184.583	2237.327	1457.155	1884.381	2207.182	1745.724	2226.584	1181.774	
1835.1	2242.281	2237.327	1788.821	1912.373	2207.182	2241.237	2226.584	984.429	
1845.1	2181.604	2237.327	1574.961	2188.712	2207.182	1695.182	2226.584	1324.703	
1855.1	2252.384	2237.327	1577.234	2226.166	2207.182	2241.237	1981.194	1582.342	
1865.1	2243.600	2237.327	1166.811	2226.166	2207.182	2241.237	2016.614	1598.074	

Table A-IV

Temperature Data Print-Out for Round 4956

Thermocouple Number	1	2	3	4	5	6	7	8
Multiplexer Channel			01	04	05	06	09	10
Time (Sec)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)
735.1	67.684	67.855	67.835	67.804	68.029	67.784	68.023	67.834
745.1	67.629	67.937	68.029	67.914	67.893	67.839	67.859	67.670
755.1	67.740	67.827	67.835	67.859	67.812	67.563	68.078	67.999
765.1	67.795	67.882	67.945	67.914	67.975	67.894	67.913	67.834
775.1	67.740	67.882	67.890	67.859	67.703	67.618	67.913	67.834
785.1	67.684	67.882	67.835	67.941	67.975	67.728	67.913	67.944
795.1	67.740	67.937	68.055	67.859	67.757	67.894	67.859	67.615
805.1	67.629	67.827	67.945	67.968	67.893	67.618	68.132	67.889
815.1	67.684	67.992	68.000	67.941	67.920	67.894	67.859	67.670
825.1	67.684	67.772	67.890	67.914	67.757	67.673	67.968	67.779
835.1	67.950	67.827	67.890	68.133	67.866	67.839	67.913	67.834
845.1	67.740	67.827	68.000	67.914	67.812	67.949	67.859	67.670
855.1	67.740	67.827	67.835	68.023	67.757	67.784	68.023	68.054
865.1	67.740	67.827	68.000	67.914	67.757	67.949	67.913	67.670
875.1	67.629	67.827	67.835	67.832	67.784	67.728	67.968	67.779
885.1	67.629	67.772	67.945	67.914	67.947	67.839	67.859	67.889
895.1	67.740	68.047	68.055	67.914	67.866	67.839	67.804	67.725
905.1	67.684	67.772	67.780	67.941	67.893	67.618	67.968	68.054
915.1	67.795	67.937	67.945	67.914	68.029	67.839	67.913	67.670
925.1	67.684	67.937	67.890	67.968	67.757	67.728	67.968	67.834
935.1	67.795	67.662	67.835	67.996	67.866	67.784	67.859	67.944
945.1	67.629	68.047	69.000	68.023	67.920	67.839	67.859	67.779
955.1	67.740	67.827	67.890	68.023	67.812	67.618	68.078	67.944
965.1	67.850	67.992	68.000	67.968	67.920	67.894	67.913	67.779
975.1	67.629	68.047	67.835	67.859	67.703	67.784	67.913	67.779
985.1	67.629	67.717	67.890	67.914	67.757	67.784	67.968	67.889
995.1	67.795	67.992	68.000	67.968	67.703	67.839	67.859	67.779
1005.1	67.684	67.607	67.781	67.914	67.703	67.673	67.859	67.834
Transition 1015.1	67.740	67.827	67.835	67.914	67.975	67.894	67.913	67.779
1025.1	67.629	67.937	67.945	67.804	67.757	67.563	67.968	67.615
1035.1	79.176	80.345	81.307	67.859	70.094	67.894	68.023	67.889
1045.1	128.099	129.745	136.245	70.512	72.104	70.428	67.913	67.834
1055.1	171.023	179.854	184.545	78.792	77.235	78.188	68.515	68.109
1065.1	199.095	221.049	219.847	98.748	86.580	89.835	69.719	68.109
1075.1	220.241	248.362	244.784	104.291	97.302	102.442	72.344	68.548
1085.1	234.711	268.634	266.227	117.538	109.426	115.513	76.333	69.756
1095.1	249.626	284.659	283.735	130.266	121.980	128.606	80.702	71.073
1105.1	263.061	296.191	298.512	142.452	134.479	141.233	86.849	73.652
1115.1	276.625	306.962	312.305	153.857	146.548	153.615	91.771	76.120
1125.1	290.638	316.504	326.958	165.211	157.066	165.156	97.706	79.190
1135.1	309.689	328.291	346.286	176.221	167.351	176.783	104.286	82.860
1145.1	333.439	350.018	373.063	188.655	177.857	189.032	110.478	86.309
1155.1	360.448	378.200	403.416	202.771	189.886	202.707	117.422	90.248
1165.1	389.246	411.895	434.207	217.971	203.745	218.128	124.574	94.239
1175.1	411.318	449.918	467.328	234.115	217.731	234.080	132.257	98.937
1185.1	436.589	493.338	501.944	250.585	234.110	251.225	140.847	103.903
1195.1	462.338	546.801	539.767	267.564	251.444	269.224	149.855	109.028
1205.1	488.439	603.497	579.396	284.971	270.939	288.548	159.495	115.074

1215.1	515.219	642.185	819.186	582.998	280.497	309.188	189.788	120.841
1225.1	543.714	679.194	855.772	521.312	309.716	330.262	180.110	127.471
1235.1	568.171	716.736	887.681	348.763	338.632	351.892	191.283	134.419
1245.1	591.483	751.515	914.787	199.426	351.461	375.838	202.749	141.683
1255.1	618.181	778.747	938.216	378.244	373.032	393.528	214.697	149.857
1265.1	636.644	802.564	744.140	394.164	395.237	412.643	226.914	157.695
1275.1	661.976	838.716	782.258	414.253	414.682	430.562	239.184	166.765
1285.1	685.774	842.049	821.093	431.845	433.554	448.896	251.243	175.600
1295.1	718.838	868.765	858.241	449.766	453.118	467.352	263.887	184.985
1305.1	735.316	422.170	680.898	468.601	472.686	485.758	276.787	194.796
1315.1	757.457	455.656	922.464	487.130	492.195	504.629	288.725	204.174
1325.1	777.293	484.828	922.680	504.746	511.912	523.819	300.661	213.996
1335.1	763.444	1019.695	478.456	522.123	532.186	543.160	313.098	223.896
1345.1	809.975	1034.886	1001.899	538.749	252.811	562.511	325.892	233.89.
1355.1	429.689	1056.726	1023.944	555.012	572.483	581.462	336.907	244.484
1365.1	842.187	1081.545	1048.340	570.885	592.762	600.877	347.970	253.948
1375.1	458.128	1104.172	1074.413	587.269	612.245	619.396	359.274	264.584
1385.1	873.696	1126.651	1101.600	603.014	631.737	638.402	376.560	275.055
1395.1	889.747	1149.263	1130.428	619.585	650.990	656.136	381.359	285.479
1402.1	904.744	1169.702	1160.830	636.781	670.554	677.904	392.191	296.352
1415.1	420.100	1140.376	1192.977	653.671	689.535	698.138	402.285	306.368
1425.1	934.588	1210.071	1222.770	670.456	708.682	718.887	412.982	316.946
1435.1	955.150	1228.493	1251.117	686.943	726.391	740.161	423.251	327.401
1445.1	973.437	1247.766	1278.606	703.777	746.017	761.928	434.620	337.630
1455.1	981.718	1268.083	1304.694	720.586	767.515	783.819	444.669	348.052
1465.1	1009.847	1291.555	1327.993	737.794	787.821	805.975	455.611	358.875
1475.1	1025.972	1313.299	1347.111	755.326	806.442	827.700	466.690	369.419
1485.1	1044.280	1333.349	1367.441	773.206	830.214	848.948	477.957	380.468
1495.1	1063.885	1356.878	1389.834	790.344	851.760	868.928	489.259	390.667
1505.1	1082.627	1347.158	1411.018	807.981	872.375	888.094	501.058	401.732
1515.1	1101.064	1383.904	1429.845	825.622	891.930	907.142	512.170	411.796
1525.1	1122.688	1398.448	1449.900	843.046	910.258	929.878	524.033	422.931
1535.1	1140.617	1413.058	1461.185	860.552	928.230	944.104	535.827	433.739
1545.1	1157.248	1426.436	1477.679	878.114	945.231	961.725	547.402	444.531
1555.1	1174.512	1437.628	1491.898	895.316	962.467	978.496	559.417	455.416
1565.1	1189.754	1449.631	1505.283	812.947	978.865	995.160	570.858	466.169
1575.1	1198.786	1461.945	1518.283	929.877	994.260	1010.631	582.840	477.171
1585.1	1215.238	1472.769	1531.097	846.304	1609.640	1026.048	594.593	487.848
1595.1	1228.884	1483.954	1543.475	962.328	1024.289	1040.771	605.898	498.305
1605.1	1246.457	1496.096	1554.962	977.214	1038.837	1055.095	617.984	509.004
1615.1	1257.998	1504.899	1565.805	993.102	1052.918	1069.122	629.452	519.535
1625.1	1206.750	1514.105	1575.950	1007.952	1065.952	1082.803	641.107	930.104
1635.1	1285.134	1522.512	1585.487	1022.945	1079.715	1096.235	652.998	541.016
1645.1	1294.795	1531.632	1595.932	1037.199	1692.308	1169.122	664.325	551.048
1655.1	1310.388	1540.861	1606.084	1051.376	1104.731	1121.419	675.789	561.627
1665.1	1323.501	1550.099	1615.447	1064.080	1116.934	1133.667	687.341	571.330
1675.1	1331.460	1559.598	1625.042	1076.031	3128.749	1145.275	698.681	581.782
1685.1	1334.665	1560.424	1632.768	1089.485	1140.370	1156.885	708.810	591.660
1695.1	1347.056	1576.599	1640.754	1101.181	1152.046	1165.151	720.928	601.289
1705.1	1357.958	1584.249	1648.138	1112.629	1162.983	1178.978	732.139	611.804
1715.1	1370.114	1592.566	1655.884	1123.766	1174.198	1189.305	742.884	621.150
1725.1	1379.226	1600.839	1663.384	1134.410	1184.679	1199.488	754.170	631.384
1735.1	1377.473	1608.868	1670.225	1144.614	1195. 55	1209.579	764.751	640.721
1745.1	1384.085	1616.493	1677.994	1154.426	1205.018	1219.374	775.869	648.863
1755.1	1389.237	1623.728	1684.336	1162.767	1215.298	1228.726	786.533	659.247
1765.1	1369.647	1631.208	1688.275	1171.454	1225.418	1238.832	787.237	668.488
1775.1	1387.893	1638.575	1696.320	1180.141	1234.694	1246.846	807.919	677.589
1785.1	1384.035	1648.757	1703.191	1188.384	1250.639	1255.662	818.326	686.623
1795.1	1388.879	1645.217	1711.147	1197.398	1272.189	1264.931	828.613	695.349
1805.1	1381.488	1643.244	1718.134	1205.169	1285.826	1273.704	838.239	705.819
1815.1	1379.826	1650.647	1725.825	1214.762	1296.785	1282.629	848.562	713.935
1825.1	1379.078	1665.226	1731.974	1223.262	1306.579	1291.978	858.188	722.884
1835.1	1383.634	1659.598	1739.738	1232.252	1316.491	1300.586	869.886	732.881
1845.1	1388.645	1643.732	1746.716	1240.611	1326.377	1309.871	878.474	748.773
1855.1	1391.592	1787.183	1754.461	1249.382	1338.516	1319.169	887.880	749.987
1865.1	1481.933	292.874	1763.618	1258.378	1345.288	1330.832	898.924	758.631

1875.1	1476.313	1575.177	1772.772	1260.459	1627.277	1342.226	915.647	776.273
1885.1	1439.404	1371.340	1791.271	1292.065	1999.230	1353.074	932.663	603.059
1895.1	1434.576	-2545.152	1789.449	1296.631	1777.824	1363.461	965.076	-673.344
1905.1	1424.423	982.474	1798.717	1305.157	1996.005	1573.746	1010.061	-152.319
1915.1	1413.724	2072.730	1806.765	1314.529	1941.376	1364.665	1226.127	-2015.183
1925.1	1411.339	2179.121	1813.497	1324.768	1056.779	1337.837	1157.684	1558.734
1935.1	1417.591	1934.676	1819.127	1335.704	1635.016	1303.616	1096.191	-693.174
1945.1	1418.344	1156.950	1826.432	1348.253	2125.546	1307.635	1048.514	-1231.061
1955.1	1416.134	1165.139	1833.326	1362.957	2209.012	1316.675	991.056	1486.411
1965.1	1459.896	1236.123	1839.702	1490.530	2209.012	1326.910	974.167	2232.056
1975.1	1463.961	1046.253	1846.090	1760.236	2209.012	1336.953	986.247	1557.752
1985.1	1456.571	1649.308	1852.534	1823.076	2209.012	1346.409	990.667	1910.530
1995.1	1449.066	1776.257	1658.649	2036.106	2207.686	1359.347	992.776	2232.056
2005.1	1432.793	1845.164	1864.443	2147.669	2140.241	1370.157	937.619	2232.056
2015.1	1456.787	1715.999	1870.905	2225.427	2179.686	1380.476	979.324	2232.056
2025.1	1476.286	161.277	1877.743	2186.709	2209.012	1391.301	972.301	2232.056
2035.1	1474.352	-1119.347	1891.290	2225.427	2209.012	1419.285	973.922	2232.056
2045.1	1482.946	-2026.723	2162.594	2225.427	2209.012	1635.905	981.661	2232.056
2055.1	1489.966	-2067.910	2232.392	2225.427	2209.012	1685.571	995.182	2232.056
2065.1	1497.601	-2067.310	1721.757	2225.427	2209.012	2017.665	1026.030	2232.056
2075.1	1504.607	-1377.296	-431.983	2225.427	2209.012	2103.999	1041.502	2232.656
2085.1	1733.167	2236.511	692.434	2225.427	2209.012	1893.231	976.618	2232.056
2095.1	2250.595	2236.511	657.965	2225.427	2209.012	2226.386	1026.566	2232.056
2105.1	2250.595	2236.511	2232.392	2225.427	2209.012	2231.354	729.565	2232.056
2115.1	2250.595	2236.511	2147.919	2225.427	2269.612	2161.232	-1131.047	2232.356
2125.1	2250.595	2236.511	2223.014	2225.427	2209.012	2213.569	37.333	2232.056
2135.1	2250.595	2236.511	2232.392	2225.427	2209.012	2233.790	445.786	1906.448
2145.1	2250.595	2236.511	2155.725	2225.427	2209.012	2186.830	631.029	1176.248
2155.1	2250.595	2236.511	2232.392	2225.427	2209.012	2233.565	610.795	2232.056
2165.1	2250.595	2236.511	2232.392	2225.427	2209.012	2079.468	962.998	2232.056
2175.1	2256.595	2236.511	2232.392	2225.427	2209.012	1886.629	1119.680	2232.056
2185.1	2250.595	2236.511	2185.501	2225.427	2209.012	1793.507	1270.765	2232.056
2195.1	2250.595	2236.511	2135.671	2164.446	2209.012	1088.125	1365.927	2232.056
2205.1	2250.595	2230.311	2232.392	1703.911	2209.012	1603.457	1494.456	2232.056
2215.1	2250.595	2236.511	2232.392	2167.465	2209.012	1540.619	1382.712	2232.056
2225.1	2250.595	2236.511	2232.392	2186.153	2209.012	1560.451	1216.667	2232.056
2235.1	2250.595	2022.923	2232.392	2142.956	2209.012	1546.216	1380.040	2232.056
2245.1	2250.595	1719.399	2232.392	2194.290	2209.012	1657.723	1331.919	2232.056
2255.1	626.602	2176.912	2232.392	2225.427	2209.012	1953.693	1734.349	2232.056
2265.1	596.488	2092.403	2232.392	2225.427	2209.012	2240.249	2152.766	2232.056
2275.1	2639.216	2236.511	2232.392	2225.427	2209.012	2186.192	1065.904	2232.056
2285.1	625.262	2236.511	2232.392	2225.427	2157.445	1966.254	1026.606	2232.056
2295.1	47.913	2236.511	2232.392	2225.427	2209.012	2012.598	1210.216	2232.056
2305.1	1904.963	2167.749	2232.392	2225.427	2209.012	2115.972	2173.506	2232.056
2315.1	2250.595	2103.962	2232.392	2225.427	2125.665	2240.246	1970.592	2232.056
2325.1	2250.595	2236.511	2232.392	2225.427	2209.012	2228.580	1602.581	2232.056
2335.1	2250.595	2236.511	2232.392	2225.427	2259.012	2218.369	1913.734	2232.056
2345.1	2250.595	2236.511	2232.392	2225.427	2209.012	2175.029	1129.916	2232.056
2355.1	2250.595	2236.511	2232.392	2225.427	2209.012	2240.249	2191.473	2232.056
2365.1	2250.595	2236.511	2232.392	2225.427	2209.012	2246.249	2225.600	2232.056
2375.1	2256.595	2236.511	2232.392	2225.427	2209.012	2240.249	2225.606	2232.056
2385.1	2256.595	2236.511	2232.392	2225.427	2209.012	2246.249	2225.606	2232.056
2395.1	1943.482	2236.511	2232.392	2225.427	2209.012	2240.249	2225.606	2232.056
2405.1	1610.856	2236.511	2232.392	2034.693	2209.012	2240.249	2225.606	2232.056
2415.1	1625.185	2236.511	2232.392	1890.042	2209.012	2240.249	2084.960	2232.056
2425.1	2087.732	2236.511	2232.392	1938.326	2209.612	2240.249	938.552	2232.056
2435.1	2250.595	2236.511	2232.392	1599.674	2167.206	2240.249	671.321	2232.656
2445.1	2250.595	2236.511	2232.352	1576.560	2126.994	2240.249	866.535	2232.056
2455.1	2250.595	2236.511	2232.392	1478.560	2118.571	2240.249	1312.119	2232.056
2465.1	2256.595	2236.511	2232.392	2225.427	2096.661	2240.249	1536.657	2232.056
2475.1	2250.595	2236.511	2232.392	2225.427	2064.237	2240.249	1894.820	2232.056
2485.1	2256.595	2236.511	2232.392	2225.427	2030.509	2208.734	2045.202	2232.056
2495.1	2250.595	2236.511	2232.392	2225.427	1999.492	2191.949	1993.661	2232.056
2505.1	2250.595	2236.511	2232.392	2225.427	1890.223	2246.246	2065.164	2232.056
2515.1	2250.595	2236.511	2232.392	2225.427	1646.064	2240.249	2027.204	2232.056
2525.1	2256.595	2236.511	2232.392	2225.427	1758.669	2240.246	2008.647	2232.056

Thermocouple No.

Multiplexer Channel

	Time (msec)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)
	739.1	75.110	75.272	75.198	75.334	77.832	75.022	74.967	75.199
	745.1	75.000	75.327	75.355	75.334	77.770	75.077	75.022	75.199
	755.1	75.110	75.272	75.409	75.334	77.778	75.187	74.858	75.034
	765.1	75.055	75.382	75.245	75.444	77.724	75.077	75.131	75.308
	775.1	75.110	75.437	75.465	75.225	77.941	75.242	74.913	75.144
	785.1	74.945	75.327	75.410	75.280	77.669	75.022	74.913	75.144
	795.1	75.055	75.217	75.300	75.280	77.832	75.132	75.022	75.199
	805.1	75.110	75.382	75.465	75.389	77.832	75.132	74.858	75.089
	815.1	75.166	75.300	75.300	75.334	77.778	75.022	75.022	75.253
	825.1	75.055	75.382	75.520	75.334	77.832	75.187	74.940	75.089
	835.1	75.000	75.217	75.330	75.170	77.615	75.242	74.858	75.089
	845.1	75.055	75.217	75.382	75.389	77.778	75.242	74.885	75.308
	855.1	75.110	75.492	75.465	75.334	77.724	75.297	74.749	75.034
	865.1	75.000	75.327	75.410	75.334	77.669	75.187	74.913	75.363
	875.1	75.110	75.217	75.410	75.225	77.832	75.352	74.913	75.199
	885.1	75.000	75.272	75.410	75.280	77.669	75.077	74.858	75.199
	895.1	75.055	75.162	75.245	75.280	77.886	75.187	75.077	75.253
	905.1	75.110	75.382	75.465	75.362	77.832	75.187	74.803	74.979
	915.1	75.000	75.272	75.355	75.334	77.832	75.022	75.131	75.308
	925.1	75.000	75.272	75.355	75.307	77.886	75.242	74.967	75.089
	935.1	74.945	75.327	75.355	75.334	77.751	75.187	74.967	75.199
	945.1	74.945	75.272	75.355	75.334	77.778	75.132	75.077	75.199
	955.1	75.055	75.437	75.520	75.280	77.778	75.187	74.803	75.[illegible]
	965.1	75.055	75.272	75.300	75.334	77.778	75.077	75.131	75.363
	975.1	75.166	75.217	75.355	75.252	77.886	75.187	74.913	75.144
	985.1	75.055	75.382	75.520	75.334	77.615	75.187	74.858	75.089
	995.1	75.000	75.217	75.190	75.225	77.778	75.297	74.967	75.199
	1005.1	75.055	75.327	75.520	75.225	77.724	75.242	74.749	74.979
Equilibrium	1015.1	74.945	75.272	75.245	75.116	77.778	75.022	75.131	75.199
	1025.1	76.326	75.767	76.671	75.334	26.804	75.187	74.913	75.034
	1035.1	107.201	93.129	105.134	75.498	61.964	75.682	75.077	74.266
	1045.1	151.716	126.066	174.951	78.640	63.282	80.522	75.409	75.089
	1055.1	194.286	166.559	240.587	84.944	49.703	93.973	75.623	78.131
	1065.1	232.944	208.275	285.329	92.086	85.965	111.022	77.644	78.370
	1075.1	266.980	237.701	324.961	101.395	88.240	131.028	80.328	81.063
	1085.1	304.038	280.937	364 920	109.166	103.053	151.252	85.178	86.430
	1095.1	345.598	312.949	405.214	119.665	119.971	173.027	89.810	99.774
	1105.1	348.562	342.819	440.732	128.663	127.703	196.331	96.128	100.149
	1115.1	420.572	367.273	467.230	141.160	109.273	218.658	103.688	109.257
	1125.1	447.603	388.511	489.376	158.095	92.679	241.648	112.812	120.037
	1135.1	468.666	408.179	506.544	172.479	95.488	261.880	122.353	129.927
	1145.1	486.306	427.063	521.683	186.688	91.759	279.777	133.238	140.341
	1155.1	502.864	445.174	535.160	197.898	119.538	297.375	141.873	151.160
	1165.1	516.175	460.353	547.597	210.668	127.709	313.024	137.379	162.838
	1175.1	532.018	473.338	558.683	224.825	115.357	328.854	139.497	173.568
	1185.1	545.118	486.815	569.978	237.904	91.613	341.367	134.389	185.460
	1195.1	557.736	496.342	581.349	250.286	94.896	355.873	132.968	196.845
	1205.1	569.977	508.216	591.946	262.906	93.549	367.127	137.824	208.978

1215.1	988.191	919.681	801.821	274.817	134.871	378.793	144.395	217.355
1225.1	990.763	929.967	811.029	285.756	127.776	390.656	148.778	227.077
1235.1	981.783	938.865	820.732	296.067	124.414	401.792	153.735	237.262
1245.1	819.930	949.347	828.159	309.516	128.210	411.122	158.957	247.215
1255.1	821.822	956.999	834.939	321.937	135.779	421.571	163.959	256.569
1265.1	831.941	966.975	845.603	338.186	96.112	432.263	169.957	265.961
1275.1	838.773	978.888	851.983	342.695	100.455	441.334	173.190	273.798
1285.1	844.484	988.133	861.812	358.331	116.045	449.926	177.276	282.535
1295.1	854.673	995.440	869.687	362.444	131.296	459.700	181.512	291.306
1305.1	865.269	805.448	874.943	372.845	121.903	468.221	185.316	299.116
1315.1	873.443	814.582	884.596	342.863	119.625	476.422	189.613	307.758
1325.1	881.548	820.866	892.152	390.899	98.546	485.439	193.077	315.705
1335.1	890.441	833.479	899.723	401.306	97.005	493.467	197.300	322.854
1345.1	897.869	843.851	906.089	410.636	100.192	501.334	201.147	329.576
1355.1	709.088	858.006	914.300	420.164	122.932	509.654	204.244	336.499
1365.1	713.212	663.869	721.059	428.853	119.327	517.299	207.980	343.419
1375.1	720.373	672.072	728.006	438.226	116.595	524.865	211.446	350.986
1385.1	720.572	678.813	735.108	446.533	120.271	532.310	214.850	357.226
1395.1	734.560	686.253	741.651	455.729	111.153	539.627	218.373	365.008
1405.1	742.332	692.131	748.741	464.195	114.088	547.346	221.461	371.308
1415.1	748.673	696.433	754.979	472.242	115.464	553.526	225.398	377.523
1425.1	755.508	705.032	761.613	480.588	122.754	561.130	228.217	383.772
1435.1	762.544	711.953	767.645	488.566	112.015	568.864	231.406	389.391
1445.1	708.772	718.018	774.173	496.945	122.998	574.892	235.017	395.992
1455.1	775.599	724.631	780.449	504.703	117.992	581.612	238.176	402.069
1465.1	782.273	730.439	787.516	513.599	119.338	587.767	241.598	409.178
1475.1	786.292	739.695	794.535	520.424	121.388	595.138	244.915	414.102
1485.1	793.606	744.848	800.651	527.624	120.546	600.675	247.960	420.111
1495.1	798.720	747.498	807.563	534.895	134.865	607.629	250.874	425.907
1505.1	805.101	753.185	814.072	542.100	140.181	611.970	253.680	431.544
1515.1	813.493	759.630	820.930	549.213	146.175	620.003	257.437	437.383
1525.1	823.751	767.978	827.431	556.870	142.410	626.335	260.081	443.475
1535.1	834.103	776.160	835.024	564.419	144.134	632.714	263.253	448.995
1545.1	843.350	784.238	844.300	572.239	151.218	639.442	266.793	454.253
1555.1	852.292	792.282	854.017	580.294	160.442	648.368	269.434	459.558
1565.1	861.378	799.614	863.728	588.237	164.623	653.088	272.917	465.941
1575.1	869.962	806.554	872.791	596.300	163.258	660.913	275.660	471.495
1585.1	877.494	813.073	880.509	604.434	177.693	666.328	279.035	477.867
1595.1	887.088	818.992	888.437	612.798	192.204	676.092	282.724	484.080
1605.1	895.092	828.083	895.594	620.501	192.352	683.144	285.779	489.724
1615.1	902.817	838.775	903.828	628.323	181.356	690.343	289.411	496.081
1625.1	908.592	835.992	909.496	635.310	201.826	696.732	292.620	501.203
1635.1	914.687	841.804	916.119	642.468	193.747	703.420	295.565	507.756
1645.1	920.143	847.813	921.940	649.790	204.291	709.952	299.031	513.842
1655.1	926.265	852.702	926.369	657.068	204.994	716.531	302.763	519.975
1665.1	931.639	857.193	933.653	664.135	207.823	722.705	306.595	526.208
1675.1	936.713	860.836	938.625	670.596	189.336	728.876	309.323	531.878
1685.1	940.643	866.850	944.610	677.203	208.835	734.391	312.365	538.708
1695.1	945.367	873.810	950.286	683.857	205.244	740.206	315.563	542.427
1705.1	949.445	878.783	955.963	690.206	206.043	746.117	318.801	548.178
1715.1	954.488	882.879	961.735	696.501	209.459	751.675	321.795	554.337
1725.1	959.487	887.339	968.098	703.392	192.652	757.731	325.355	559.877
1735.1	964.532	894.917	974.213	709.930	202.385	762.634	328.127	565.318
1745.1	969.178	899.845	979.834	715.441	191.621	768.735	331.284	570.900
1755.1	973.688	902.838	985.652	721.209	208.958	773.534	334.557	575.627
1765.1	978.919	909.128	991.074	727.830	206.120	777.781	338.448	581.106
1775.1	983.639	912.294	996.840	733.504	208.349	783.676	339.884	589.973
1785.1	988.484	917.514	1002.686	739.826	230.657	787.828	343.485	594.940
1795.1	994.015	923.772	1008.020	745.548	210.631	792.814	346.486	595.781
1805.1	998.934	926.740	1014.185	751.147	138.447	797.004	349.691	600.763
1815.1	1003.192	931.843	1019.555	757.082	207.548	801.564	352.688	606.125
1825.1	1008.188	938.805	1025.170	761.970	214.088	806.968	354.757	611.038
1835.1	1012.931	942.463	1030.884	768.086	195.010	811.716	358.058	617.788
1845.1	1018.844	947.109	1036.644	773.373	180.388	816.600	361.405	620.932
1855.1	1023.158	951.813	1041.866	779.179	181.233	822.838	364.322	625.977
1865.1	1028.288	955.989	1047.332	784.883	182.258	826.413	367.398	630.724

1975.1	1031.428	940.492	1164.496	790.042	217.394	836.344	370.352	635.414
1985.1	1038.341	964.994	1257.949	789.642	199.572	834.728	373.314	640.192
1995.1	1043.253	969.637	1263.334	802.240	179.623	839.256	376.274	645.241
2005.1	1048.314	979.231	1268.750	806.143	197.399	843.684	379.921	649.672
2015.1	1053.175	980.106	1273.939	812.307	200.288	847.863	382.656	654.555
2025.1	1057.248	989.440	1278.598	817.133	202.309	851.581	385.249	659.284
2035.1	1062.601	989.819	1283.716	822.575	207.829	857.360	387.945	664.263
2045.1	1069.218	995.140	1289.839	827.719	196.907	860.938	391.105	668.739
2055.1	1071.776	995.812	1293.611	832.781	187.056	864.218	393.958	673.356
2065.1	1078.492	1002.951	1298.504	837.788	210.742	867.199	396.594	678.290
2075.1	1081.499	1007.447	1303.851	843.042	207.209	871.670	400.061	681.944
2085.1	1086.283	1012.089	1308.673	848.279	216.988	875.395	402.596	686.662
2095.1	1091.718	1015.637	1314.042	853.369	194.259	879.864	405.750	691.627
2105.1	1099.430	1020.422	1319.113	858.401	212.123	883.091	408.499	695.738
2115.1	1101.837	1024.072	1324.574	863.781	184.188	887.410	411.899	700.950
2125.1	1108.549	1026.412	1329.699	868.715	196.779	893.269	414.429	704.156
2135.1	1111.797	1032.694	1334.967	873.950	210.608	897.681	418.042	708.214
2145.1	1117.019	1037.191	1339.941	878.777	190.973	902.492	420.873	712.718
2155.1	1122.819	1040.645	1344.522	884.250	179.273	906.757	424.025	717.872
2165.1	1128.722	1045.623	1350.282	889.130	190.467	911.319	426.654	722.124
2175.1	1135.767	1050.948	1357.079	894.797	198.660	916.524	429.333	726.674
2185.1	1142.445	1056.224	1363.679	900.019	176.335	920.885	432.784	730.672
2195.1	1149.668	1061.204	1370.272	905.930	213.506	926.286	435.719	735.269
2205.1	1156.216	1066.183	1377.923	911.593	187.127	932.033	438.961	739.505
2215.1	1162.413	1070.945	1384.421	917.697	208.449	938.293	442.459	744.607
2225.1	1168.871	1075.205	1390.533	923.185	194.506	941.889	445.235	749.340
2235.1	1173.432	1080.214	1396.856	929.262	196.169	945.454	448.473	753.936
2245.1	1179.694	1084.818	1401.180	934.376	192.069	950.950	451.914	758.477
2255.1	1183.689	1089.156	1406.781	940.723	199.609	955.058	455.201	763.862
2265.1	1190.574	1092.854	1411.462	945.714	202.796	958.968	458.242	768.498
2275.1	1193.093	1097.241	1417.006	951.098	214.179	964.411	461.512	772.631
2285.1	1197.593	1100.692	1422.187	956.505	201.082	969.062	465.460	777.710
2295.1	1201.884	1105.523	1428.072	961.420	207.253	975.295	468.433	782.041
2305.1	1206.783	1108.727	1431.807	966.285	203.127	981.379	471.917	786.272
2315.1	1211.422	1113.341	1436.717	972.034	200.702	985.385	474.887	791.197
2325.1	1215.775	1117.207	1441.283	976.940	175.129	991.863	477.858	795.872
2335.1	1219.820	1120.806	1445.528	982.153	173.008	995.868	481.898	800.098
2345.1	1224.343	1124.143	1449.872	986.770	183.707	1002.442	484.762	804.970
2355.1	1228.816	1128.300	1454.415	991.926	200.138	1006.522	488.084	808.647
2365.1	1233.440	1131.652	1459.156	996.664	191.529	1011.685	491.908	813.863
2375.1	1237.415	1136.455	1463.967	1001.206	221.477	1017.962	493.989	817.339
2385.1	1242.191	1140.232	1468.859	1006.753	199.741	1023.348	497.463	822.105
2395.1	1246.767	1144.702	1473.781	1011.465	197.923	1028.684	500.392	826.828
2305.1	1250.896	1147.875	1478.155	1016.520	209.861	1033.477	503.657	830.244
2315.1	1256.870	1151.870	1482.530	1021.281	224.958	1037.973	506.672	834.610
2325.1	1260.499	1155.963	1486.634	1026.090	234.473	1043.654	509.826	838.528
2335.1	1265.028	1159.909	1490.986	1031.193	257.776	1052.594	512.833	842.594
2345.1	1269.509	1163.707	1495.388	1036.394	242.543	1061.098	518.144	848.857
2355.1	1274.486	1167.456	1499.404	1041.398	231.157	1063.708	518.588	850.822
2365.1	1278.721	1170.909	1503.849	1046.500	234.676	1067.412	522.987	855.438
2375.1	1282.905	1174.995	1507.957	1051.553	222.052	1073.388	525.283	898.997
2385.1	1287.015	1179.050	1512.462	1056.230	264.866	1079.277	528.255	863.009
2395.1	1291.425	1182.356	1516.671	1060.824	229.617	1083.219	531.559	867.089
2405.1	1296.389	1186.501	1521.773	1066.367	270.647	1087.611	534.987	871.838
2415.1	1300.347	1190.301	1525.934	1071.875	309.440	1091.611	537.483	875.583
2425.1	1304.695	1193.904	1530.196	1075.538	291.232	1097.093	540.399	879.295
2435.1	1308.974	1197.803	1534.062	1080.639	276.987	1102.278	543.546	883.995
2445.1	1312.964	1201.955	1537.393	1085.397	298.771	1108.383	548.548	887.699
2455.1	1317.855	1205.183	1540.954	1089.860	337.580	1112.896	550.848	891.364
2465.1	1321.766	1209.467	1544.127	1094.715	356.482	1117.242	552.728	899.884
2475.1	1326.786	1212.219	1547.848	1099.816	345.739	1121.292	555.668	899.728
2485.1	1330.732	1215.577	1551.966	1104.230	398.333	1125.441	558.759	903.822
2495.1	1335.077	1218.168	1555.092	1108.423	454.856	1129.491	561.788	907.479
2505.1	1336.273	1222.665	1559.262	1113.598	431.128	1132.850	564.927	911.284
2515.1	1343.328	1226.444	1562.936	1117.840	534.141	1136.782	568.785	915.738
2525.1	1347.969	1229.992	1566.939	1122.525	516.498	1141.428	570.999	918.843

2535.1	1352.287	1234.813	1370.436	1126.693	592.737	1144.754	573.693	922.842
2545.1	1359.667	1237.164	1374.117	1131.427	614.416	1148.706	577.079	926.694
2555.1	1360.869	1241.120	1378.013	1135.726	625.458	1150.613	580.112	930.367
2565.1	1363.478	1244.331	1381.987	1140.331	715.978	1153.498	581.191	934.445
2575.1	1367.223	1246.690	1385.048	1144.501	787.938	1157.696	586.275	938.443
2585.1	1370.324	1251.796	1388.578	1146.769	740.691	1160.762	589.951	941.759
2595.1	1374.131	1255.457	1391.862	1152.744	799.985	1164.171	591.776	945.748
2605.1	1377.215	1259.265	1395.296	1157.656	818.192	1168.075	594.932	949.397
2615.1	1380.982	1262.134	1398.361	1160.791	848.696	1171.031	597.984	953.344
2625.1	1384.248	1265.844	1401.617	1145.562	854.917	1176.632	600.505	956.608
2635.1	1387.484	1269.208	1405.197	1169.477	872.961	1180.135	603.533	960.693
2645.1	1391.414	1272.474	1406.439	1173.109	876.853	1183.792	606.705	964.095
2655.1	1395.274	1275.938	1412.024	1177.338	926.077	1188.242	609.274	967.843
2665.1	1399.035	1278.956	1415.145	1180.963	945.766	1191.956	612.724	971.688
2675.1	1402.395	1282.522	1418.854	1184.792	980.880	1196.153	615.247	974.548
2685.1	1405.554	1286.141	1422.194	1189.014	980.801	1200.010	618.488	978.738
2695.1	1408.160	1289.465	1425.036	1192.427	1604.920	1203.471	621.258	982.139
2705.1	1412.984	1292.624	1426.376	1196.429	1622.418	1206.765	624.123	985.638
2715.1	1415.599	1296.141	1431.521	1200.260	1036.860	1209.951	626.889	989.135
2725.1	1419.613	1299.466	1434.664	1204.236	1066.973	1213.760	629.754	992.438
2735.1	1423.936	1302.731	1437.989	1207.775	1079.301	1217.371	632.719	996.133
2745.1	1426.942	1305.902	1441.180	1211.568	1091.675	1220.884	635.382	999.582
2755.1	1430.617	1309.372	1444.800	1215.045	1105.364	1224.348	638.945	1003.080
2765.1	1433.685	1312.991	1446.646	1219.326	1126.028	1227.961	641.529	1006.626
2775.1	1437.606	1315.817	1450.896	1222.539	1112.965	1231.525	644.521	1009.828
2785.1	1440.779	1319.339	1454.544	1226.710	1130.406	1235.039	647.088	1013.473
2795.1	1444.197	1322.612	1457.294	1230.280	1145.317	1236.604	649.990	1016.920
2805.1	1447.770	1325.688	1459.995	1233.967	1081.655	1242.367	653.099	1020.220
2815.1	1450.942	1328.812	1462.996	1237.506	1081.195	1245.239	655.757	1023.667
2825.1	1454.508	1331.935	1465.797	1240.973	1004.202	1249.003	658.714	1026.917
2835.1	1457.691	1335.365	1468.950	1244.907	922.194	1252.222	661.678	1030.560
2845.1	1461.268	1338.334	1472.204	1248.670	859.816	1255.442	664.275	1034.007
2855.1	1464.897	1341.522	1475.108	1252.310	621.567	1258.960	667.088	1037.158
2865.1	1468.074	1344.902	1478.514	1255.635	641.248	1262.180	670.435	1040.850
2875.1	1471.795	1347.258	1481.420	1259.542	989.875	1266.145	672.887	1043.804
2885.1	1474.782	1350.711	1484.677	1263.164	986.193	1268.970	675.840	1047.299
2895.1	1478.163	1353.444	1487.935	1267.121	982.929	1272.539	678.992	1051.040
2905.1	1481.648	1356.575	1490.994	1270.911	983.066	1275.861	681.742	1054.101
2915.1	1484.877	1359.806	1494.404	1274.235	982.404	1279.133	684.842	1057.685
2925.1	1488.463	1362.541	1497.565	1277.657	988.680	1282.903	687.492	1060.245
2935.1	1491.949	1366.071	1501.028	1281.498	595.344	1286.077	690.448	1064.084
2945.1	1495.588	1369.304	1504.492	1285.143	990.781	1289.698	692.988	1067.234
2955.1	1498.773	1372.563	1507.957	1289.232	589.324	1292.923	695.935	1070.532
2965.1	1502.384	1375.374	1510.971	1292.898	592.184	1296.496	698.981	1074.075
2975.1	1505.854	1378.709	1514.690	1295.983	593.791	1300.368	701.727	1076.782
2985.1	1509.346	1381.496	1517.555	1299.976	591.233	1303.396	704.821	1080.621
2995.1	1512.637	1384.683	1520.773	1303.476	586.389	1307.268	707.416	1083.771
3005.1	1516.437	1387.671	1523.891	1307.223	583.056	1310.546	710.389	1086.822
3015.1	1520.132	1391.267	1527.715	1311.070	584.336	1314.023	713.102	1090.808
3025.1	1523.527	1394.240	1530.433	1314.270	585.717	1317.450	716.193	1093.122
3035.1	1527.388	1397.436	1534.058	1318.223	585.663	1320.680	719.383	1097.305
3045.1	1531.234	1400.725	1537.180	1321.924	591.083	1324.208	721.925	1100.912
3055.1	1534.684	1403.966	1540.606	1325.628	587.824	1327.988	724.715	1103.211
3065.1	1537.992	1407.157	1543.882	1329.326	589.679	1331.018	727.783	1106.951
3075.1	1541.383	1410.100	1546.806	1332.739	591.259	1334.697	730.293	1109.668
3085.1	1544.436	1413.193	1549.932	1336.389	591.284	1337.930	733.479	1113.201
3095.1	1547.325	1415.918	1552.959	1340.391	593.966	1341.312	735.267	1116.400
3105.1	1550.882	1419.182	1556.087	1344.647	594.240	1344.895	738.994	1119.488
3115.1	1554.135	1422.402	1559.217	1347.358	593.639	1347.930	742.287	1122.648
3125.1	1557.186	1425.523	1562.044	1350.921	593.315	1351.314	744.688	1125.457
3135.1	1560.441	1428.170	1565.226	1354.624	596.344	1354.688	747.957	1128.952
3145.1	1563.952	1431.268	1568.106	1357.744	594.095	1357.938	750.343	1131.888
3155.1	1567.511	1434.216	1570.936	1361.698	593.441	1360.924	753.325	1134.858
3165.1	1570.621	1436.715	1573.767	1364.912	595.344	1364.062	756.884	1138.058
3175.1	1573.277	1440.114	1576.981	1368.227	598.894	1367.588	759.089	1141.155
3185.1	1577.197	1442.790	1579.887	1371.988	599.147	1370.689	761.921	1144.587

3195.1	1588.557	1445.816	1583.177	1375.404	600.393	1373.630	765.349	1147.599
3205.1	1594.025	1449.117	1599.214	1379.117	598.477	1376.920	797.581	1150.070
3215.1	1587.136	1452.320	1569.297	1382.434	602.633	1380.061	771.205	1153.793
3225.1	1596.880	1455.774	1592.951	1385.970	602.158	1383.652	773.468	1159.619
3235.1	1591.460	1458.976	1599.348	1399.699	603.635	1386.595	776.267	1159.910
3245.1	1598.528	1462.239	1600.892	1392.888	604.612	1389.818	778.995	1162.724
3255.1	1599.649	1465.370	1603.944	1396.584	605.138	1393.432	782.169	1165.975
3265.1	1601.627	1449.040	1607.251	1399.832	906.239	1398.779	794.047	1169.020
3275.1	1585.573	1471.554	1611.087	1403.403	609.114	1400.421	787.822	1171.983
3285.1	1600.190	1474.412	1615.262	1406.827	609.718	1403.717	790.796	1172.620
3295.1	1611.914	1477.722	1618.372	1409.903	605.313	1406.914	793.125	1178.189
3305.1	1618.022	1500.738	1622.842	1413.873	607.890	1410.552	796.591	1183.903
3315.1	1620.770	1592.582	1629.761	1417.390	699.906	1413.711	790.714	1275.493
3325.1	1626.354	1675.203	1631.006	1421.093	622.495	1417.239	603.874	1384.191
3335.1	1631.013	1769.670	1636.533	1440.623	958.993	1421.391	809.172	1549.270
3345.1	1640.282	1759.332	1643.286	1449.927	1024.670	1424.712	815.902	1731.317
3355.1	1647.832	1879.449	1650.900	1442.947	1030.950	1420.912	826.339	1939.929
3365.1	1637.863	1993.675	1655.224	1449.715	1210.859	1464.421	839.183	1952.097
3375.1	1625.276	2119.317	1660.320	1460.473	1030.832	1565.111	848.229	1339.137
3385.1	1625.093	2100.290	1672.184	1482.591	1265.621	1640.794	856.375	-730.092
3395.1	1633.039	2151.423	1676.399	1498.997	1133.924	1696.901	863.185	920.073
3405.1	1645.800	2222.340	1685.670	1474.432	-1994.246	1714.906	869.086	-1360.838
3415.1	1660.556	2602.376	1693.081	1480.990	-2819.994	1704.337	873.790	-190.563
3425.1	1689.024	1890.300	1703.111	1465.169	-2819.994	1683.226	879.214	1982.786
3435.1	1675.380	1711.239	1711.939	1490.475	-913.340	1585.336	884.636	2195.859
3445.1	1679.402	1824.340	1731.402	1492.558	1410.870	1590.761	890.402	1070.644
3455.1	1693.332	1441.270	1917.613	1498.656	1821.707	1699.307	896.708	1939.214
3465.1	1695.750	1485.563	1931.324	1506.507	1880.409	1845.976	903.701	1633.558
3475.1	1685.184	2115.857	1917.770	1509.559	1983.141	1864.406	909.166	2214.042
3485.1	1691.748	1639.081	1948.479	1540.760	2167.424	1690.771	914.778	1922.830
3495.1	1695.107	1774.509	2159.724	1607.534	2209.427	1701.422	922.897	2094.944
3505.1	1700.019	1801.534	2220.931	1520.511	2177.487	1748.308	958.348	2201.189
3515.1	1721.151	1814.798	2226.911	1431.180	1983.361	1569.511	955.572	2043.540
3525.1	1660.574	1983.078	2294.796	1673.736	2035.321	1455.647	990.419	2232.799
3535.1	1920.945	2105.890	2235.256	1847.050	2110.415	1373.171	1344.523	2162.685
3545.1	2076.113	1849.997	2074.210	1926.896	2155.457	1203.973	1898.309	2156.118
3555.1	2157.806	1937.579	2087.096	1838.525	2209.427	1153.502	1957.396	2130.531
3565.1	1639.119	1986.299	2229.383	1867.980	2209.427	1133.245	2027.476	2203.747
3575.1	1731.280	1743.530	2233.517	2098.309	2209.427	1140.210	2031.892	2232.799
3585.1	1996.710	1847.081	2033.469	2088.957	1318.625	1150.438	2034.373	2182.388
3595.1	2220.813	1863.698	2126.863	2056.791	1128.984	1167.853	1987.483	2213.838
3605.1	2250.950	1970.025	2119.781	2038.891	1367.475	1175.390	1893.208	2031.889
3615.1**	2250.950	2237.045	2212.210	2028.044	[illegible]	[illegible]	1394.990	2229.715
3625.1	2250.950	1957.262	1999.965	2039.285	1823.283	1203.852	1346.389	2117.027
3635.1	2250.950	2225.742	1936.928	2134.199	1970.131	1162.097	1119.235	1945.178
3645.1	1796.230	2183.071	2207.318	2160.276	1878.203	1294.577	1138.847	1894.754
3655.1	1524.834	2237.045	2235.256	2178.805	1918.343	1502.538	1192.497	1848.978
3665.1	1869.386	2237.045	2235.256	2157.242	574.848	1502.976	1031.289	1743.441
3675.1	1911.002	2237.045	2235.259	2157.682	-235.829	1458.732	983.157	1733.393
3685.1	1948.798	2237.045	2235.256	2197.118	339.864	1484.424	1050.918	1654.378
3695.1	1980.022	2237.045	2235.259	2026.028	1906.491	1418.016	1330.988	1989.177
3705.1	2126.426	2237.049	2235.259	2226.026	1821.329	1298.248	1377.367	1657.537
3715.1	2227.082	2237.345	2235.259	2026.026	1476.964	1249.599	1376.823	1679.090
3725.1	2197.427	2231.771	2235.256	2226.029	1515.153	1246.576	1394.216	1683.749
3735.1	2058.876	2185.735	2223.262	2226.026	1465.286	1250.785	1326.527	1692.981
3745.1	2051.285	1795.159	2197.959	2226.825	1369.331	1237.278	1352.582	1699.125
3755.1	2083.078	1735.836	2181.771	2226.026	1335.326	1172.364	1341.488	1734.920
3765.1	2143.994	1698.803	2030.045	2226.026	1199.808	1206.940	1367.328	1744.928
3775.1	2170.044	1667.786	1984.647	2226.026	1228.723	1328.849	1374.496	1738.881
3785.1	2165.843	1937.709	1905.783	2226.826	1290.928	1305.226	1507.888	1727.688
3795.1	2157.358	1815.785	1807.174	2226.026	1375.792	1387.943	1647.183	1740.288
3805.1	2185.597	1528.227	1729.979	2026.026	1369.980	1389.839	1685.741	1898.589
3815.1	2184.343	1579.891	1697.361	2226.826	1480.498	1363.818	1693.424	1688.486
3825.1	2280.781	1545.899	1687.671	2226.026	1385.497	1335.147	1793.681	1689.841
3835.1	2208.021	1588.492	1668.264	2228.886	1011.092	1482.918	1813.386	1689.431
3845.1	2225.989	1516.936	1643.513	2226.826	1881.949	1402.869	1819.529	1691.930

3855.1	2245.560	1613.344	1622.444	2226.616	1377.183	1403.617	1838.789	1668.713
3865.1	2244.422	1954.531	1560.745	2224.076	1320.165	1401.520	1659.605	1961.340
3875.1	2253.022	1987.030	1581.103	2224.026	1326.495	1408.364	1878.922	1670.340
3885.1	2247.324	2012.324	1563.712	1412.770	1324.415	1417.911	1883.886	1656.469
3895.1	2235.635	2007.681	1549.378	1726.025	1354.552	1419.611	1898.289	1649.539
3905.1	2241.944	2237.049	1536.226	1607.539	1431.367	1426.910	1894.151	1639.013
3915.1	2237.877	2237.045	1518.571	1603.549	1360.070	1435.122	1907.001	1633.020
3925.1	2226.409	2237.049	1449.732	1562.903	1371.346	1439.429	1910.199	1626.986
3935.1	2287.962	2237.045	1456.747	1521.233	1372.110	1442.234	1926.005	1622.073
3945.1	2195.414	2237.049	1426.196	1429.837	1373.833	1445.791	1926.495	1905.973
3955.1	2182.396	2237.045	1396.442	1432.860	1441.422	1448.307	1931.616	1561.177
3965.1	2163.041	2002.172	1343.359	1423.706	1481.690	1452.909	1946.953	1565.508
3975.1	2152.027	2227.507	1357.060	1400.201	1496.335	1453.210	1936.253	1573.360
3985.1	2131.666	2237.045	1329.463	1399.193	1506.419	1454.714	1929.194	1563.767
3995.1	2130.839	2237.045	1303.801	1347.211	1511.013	1457.573	1922.028	1549.442
4005.1	2131.964	2092.303	1278.032	1315.319	1511.705	1458.927	1903.787	1529.449
4015.1	2089.223	2087.458	1253.120	1282.125	1519.792	1456.676	1892.257	1505.874
4025.1	2092.147	1815.952	1221.990	1251.619	1517.294	1459.276	1883.426	1481.855
4035.1	2083.925	1866.556	1196.763	1222.761	1522.978	1459.128	1874.821	1458.038
4045.1	2040.034	1816.616	1170.921	1196.037	1527.061	1459.120	1866.645	1434.464
4055.1	2014.920	1813.855	1148.817	1169.036	1516.634	1458.275	1858.470	1411.234
4065.1	1960.109	1815.967	1128.517	1142.343	1512.764	1457.073	1848.552	1389.238
4075.1	1898.339	1818.035	1112.221	1116.590	1448.620	1457.073	1840.022	1367.523
4085.1	1839.990	1819.185	1097.690	1093.244	1431.033	1456.921	1832.401	1347.656
4095.1	1917.758	1819.342	1085.784	1070.830	1418.992	1450.670	1823.838	1328.293
4105.1	1694.779	1819.446	1075.399	1049.272	1411.717	1450.620	1814.946	1310.121
4115.1	1875.897	1817.826	1066.535	1029.034	1302.133	1455.707	1800.179	1293.103
4125.1	1657.364	1815.161	1058.952	1009.156	1350.760	1455.216	1797.224	1276.519
4135.1	1839.151	1819.213	1052.059	991.207	1331.601	1453.902	1788.107	1261.330
4145.1	1865.541	1814.429	1046.249	975.129	1244.200	1452.909	1762.007	1246.026
4155.1	1848.184	1812.947	1041.127	958.372	1212.047	1451.505	1773.762	1231.373
4165.1	1829.765	1810.905	1036.449	941.706	1205.230	1449.801	1764.317	1217.712
4175.1	1854.237	1807.955	1032.213	924.435	1103.028	1448.048	1759.341	1204.500
4185.1	1662.068	1805.346	1028.717	909.229	1104.752	1445.041	1751.651	1191.963
4195.1	1851.546	1801.644	1025.466	894.288	1179.437	1443.536	1742.069	1179.667
4205.1	1839.084	1767.310	1022.510	880.602	1205.044	1441.232	1733.282	1167.359
4215.1	1828.128	1792.266	1019.850	866.692	1212.142	1438.427	1723.890	1155.929
4225.1	1817.226	1784.645	1017.209	852.970	1202.109	1435.973	1714.177	1144.162
4235.1	1806.038	1779.366	1015.318	842.440	1201.725	1433.320	1705.243	1133.677
4245.1	1795.912	1773.703	1013.692	830.760	1210.605	1430.118	1696.448	1122.897
4255.1	1781.828	1768.279	1012.214	840.028	1205.921	1427.464	1688.021	1112.758
4265.1	1766.345	1741.978	1010.986	827.807	1203.847	1424.212	1679.092	1103.014
4275.1	1688.931	1755.501	1009.110	820.003	1214.655	1421.011	1669.669	1093.318
4285.1	1622.104	1745.134	1007.977	815.549	1220.073	1417.660	1660.706	1084.411
4295.1	1685.428	1742.410	1067.140	808.074	1210.950	1414.461	1651.758	1075.404
4305.1	1593.465	1736.304	1006.253	800.340	1220.048	1411.212	1642.870	1066.939
4315.1	1584.892	1730.684	1005.513	793.113	1217.503	1407.514	1634.144	1058.571
4325.1	1579.945	1724.313	1004.972	784.902	1214.055	1409.217	1625.477	1050.687
4335.1	1579.283	1717.792	1004.429	780.022	1106.380	1400.621	1616.870	1042.426
4345.1	1939.756	1713.620	1004.232	769.090	1083.320	1396.920	1608.271	1034.795
4355.1	1669.399	1708.370	1003.906	774.167	1078.327	1393.631	1600.338	1027.311
4365.1	1662.150	1702.246	1003.444	706.055	1068.096	1365.605	1592.512	1020.072
4375.1	1652.274	1696.963	1003.198	763.144	1064.199	1386.445	1584.240	1012.931
4385.1	1942.512	1669.916	1002.653	757.077	1056.449	1362.505	1576.630	1006.009
4395.1	1632.916	1682.581	1002.508	752.659	1053.026	1379.114	1568.523	999.237
4405.1	1624.151	1476.070	1002.409	747.706	1046.461	1375.673	1560.724	992.305
4415.1	1615.190	1669.028	1001.867	742.712	1043.929	1371.935	1552.882	986.475
4425.1	1606.646	1662.452	1001.670	738.233	1040.226	1368.946	1544.556	980.167
4435.1	1597.959	1655.395	1001.473	733.720	1036.660	1364.989	1537.367	974.498
4445.1	1560.667	1647.936	1001.177	725.122	1031.991	1361.522	1526.453	968.527
4455.1	1579.997	1641.396	1001.029	724.680	1026.872	1357.637	1522.026	963.356
4465.1	1571.407	1634.313	1000.032	720.173	1021.364	1354.102	1514.615	958.075
4475.1	1563.087	1627.587	1000.734	716.164	1015.985	1350.717	1507.089	952.752
4485.1	1554.542	1620.014	1000.537	712.025	1011.070	1347.034	1995.088	948.166
4495.1	1546.411	1613.805	1000.487	708.333	1007.129	1343.808	1492.402	943.032
4505.1	1539.300	1607.104	1000.309	704.515	1003.277	1339.168	1485.271	938.344

735.1	76.251	76.447	76.446	76.544	76.577	76.525	76.552	76.289
745.1	76.306	76.659	76.556	76.591	76.495	76.470	76.552	76.453
755.1	76.251	76.447	76.401	76.646	76.468	76.305	76.770	76.453
765.1	76.361	76.632	76.721	76.537	76.632	76.635	76.661	76.289
775.1	76.251	76.577	76.501	76.564	76.305	76.360	76.661	76.398
785.1	76.306	76.522	76.611	76.646	76.468	76.470	76.606	76.453
795.1	76.251	76.851	76.556	76.537	76.464	76.580	76.552	76.398
805.1	76.306	76.467	76.446	76.640	76.358	76.140	76.775	76.563
815.1	76.416	76.632	76.556	76.646	76.468	76.635	76.606	76.289
825.1	76.251	76.632	76.611	76.537	76.413	76.360	76.661	76.289
835.1	76.251	76.412	76.556	76.537	76.522	76.470	76.606	76.508
845.1	76.251	76.577	76.611	76.591	76.468	76.580	76.606	76.343
855.1	76.251	76.412	76.446	76.591	76.413	76.250	76.661	76.563
865.1	76.416	76.577	76.666	76.591	76.577	76.690	76.552	76.289
875.1	76.251	76.522	76.611	76.537	76.413	76.360	76.606	76.508
885.1	76.306	76.467	76.611	76.537	76.577	76.525	76.606	76.508
895.1	76.251	76.687	76.611	76.646	76.468	76.580	76.661	76.289
905.1	76.334	76.467	76.446	76.646	76.440	76.415	76.770	76.618
915.1	76.361	76.687	76.611	76.646	76.577	76.635	76.497	76.289
925.1	76.251	76.412	76.391	76.537	76.413	76.415	76.661	76.453
935.1	76.361	76.577	76.611	76.619	76.522	76.470	76.606	76.398
945.1	76.306	76.632	76.666	76.673	76.413	76.525	76.497	76.343
955.1	76.306	76.522	76.501	76.482	76.358	76.195	76.770	76.618
965.1	76.306	76.577	76.611	76.619	76.577	76.525	76.606	76.234
975.1	76.251	76.577	76.556	76.619	76.358	76.360	76.661	76.398
985.1	76.416	76.632	76.611	76.482	76.522	76.525	76.552	76.398
995.1	76.361	76.577	76.611	76.646	76.468	76.635	76.497	76.289
1005.1	76.195	76.357	76.556	76.537	76.303	76.360	76.606	76.618
1015.1	76.306	76.522	76.556	76.373	76.413	76.580	76.497	76.343
1025.1	76.195	76.412	76.336	76.482	76.358	76.360	76.606	76.343
1035.1	82.546	79.979	82.810	84.573	77.[illegible]0	75.864	75.951	76.563
1045.1	107.658	120.141	111.349	78.449	76.742	76.195	75.896	76.069
1055.1	147.486	140.513	154.383	81.725	83.343	76.745	76.661	76.343
1065.1	174.307	219.835	193.927	90.357	95.730	77.570	78.027	76.234
1075.1	200.840	255.848	221.596	101.612	110.241	78.340	81.357	76.837
1085.1	225.983	280.758	243.594	114.757	126.127	80.100	86.103	77.824
1095.1	246.291	299.064	258.181	127.113	141.099	82.848	92.098	78.427
1105.1	264.017	312.309	271.724	139.252	155.384	86.309	98.739	80.509
1115.1	279.024	322.580	279.675	151.149	168.176	89.987	105.916	83.029
1125.1	291.120	331.415	291.741	162.188	179.540	93.553	113.02*	86.096
1135.1	302.714	338.874	303.995	172.667	190.264	97.355	120.349	89.105
1145.1	313.597	349.481	316.857	183.127	200.184	101.173	127.443	91.843
1155.1	333.032	371.004	342.650	194.156	210.127	105.933	134.311	96.977
1165.1	374.229	445.996	399.129	205.964	221.355	110.765	141.171	108.199
1175.1	450.662	544.303	498.042	223.124	237.994	114.571	149.209	124.674
1185.1	546.313	647.166	617.636	250.333	265.677	119.704	158.364	148.764
1195.1	644.194	744.083	731.833	286.957	302.040	126.141	170.486	113.232
1205.1	733.919	830.795	834.383	330.298	345.214	134.894	187.881	119.118

1215.1	817.078	901.284	926.818	878.887	395.841	178.878	206.856	125.208
1225.1	892.282	974.882	1087.187	428.888	444.989	198.181	230.359	132.857
1239.1	988.014	1039.818	1079.572	488.288	457.883	172.988	295.833	142.988
1345.1	1038.633	1095.257	1149.521	514.488	548.325	188.182	282.938	153.278
1255.1	1112.628	1159.787	1211.623	561.825	599.938	283.393	311.948	166.131
1265.1	1174.572	1218.884	1277.886	688.882	658.181	218.965	341.966	188.885
1379.1	1228.582	1273.764	1338.857	854.582	858.683	234.818	372.892	194.971
1285.1	1279.888	1342.471	1384.891	699.591	1118.488	263.626	484.525	213.135
1295.1	1324.333	1488.418	1454.715	743.483	1819.893	259.228	438.182	229.187
1385.1	1378.895	2815.844	1725.344	787.281	2168.412	492.127	477.826	1427.475
1315.1	1427.587	1998.851	2172.324	858.887	1682.588	547.472	572.837	1281.398
1325.1	1944.334	1747.418	2088.928	925.288	1976.473	1982.352	788.869	1579.648
1335.1	3044.823	1988.778	2238.858	1188.294	1984.347	1958.887	864.928	1812.816
1345.1	2352.994	2817.713	2282.275	1278.271	2842.127	1925.668	925.644	2853.888
1355.1	2353.335	2849.883	1764.791	1369.128	2118.888	2241.388	985.759	2151.378
1365.1	2293.335	2642.858	2338.858	1518.868	2128.623	2179.546	1816.237	1484.272
1375.1	2293.335	2154.968	2223.188	2848.521	1983.182	2194.958	1858.128	1621.388
1385.1	2293.335	2865.269	2238.858	2226.388	2887.883	2241.388	1889.788	1472.418
1395.1	2293.335	2113.873	2338.859	2228.386	2233.389	3341.388	1124.863	1598.243
1485.1	2293.335	1772.933	2286.939	2226.386	-116.995	2218.878	1141.115	2878.311
1415.1	3293.335	2198.343	1882.311	3226.388	1248.927	1957.743	1282.148	2233.382
1425.1	2293.335	2224.858	2224.283	2226.386	2248.417	2241.388	1247.556	1972.518
1435.1	2293.335	2129.463	377.219	2228.388	1489.347	2239.338	1395.885	1912.754
1445.1	2293.335	2112.778	-2283.582	2226.386	1928.887	2157.244	1475.238	1572.838
1455.1	2393.335	2139.188	1733.758	3228.386	1845.882	3241.388	1781.327	1328.927
1465.1	2293.335	2278.888	2282.477	2224.386	1458.885	2148.788	2878.748	1552.832
1475.1	2293.335	2836.754	2238.858	2228.886	1831.458	3241.388	1833.887	2188.859
1485.1	2293.335	2887.182	2238.858	2226.386	2174.395	2241.388	2191.978	2233.382
1495.1	2293.335	1592.278	3238.858	2228.388	1278.842	3241.388	2325.888	2233.382
1585.1	2273.335	1973.263	2223.188	2226.386	275.267	2238.978	2225.886	2233.382
1515.1	2293.335	1943.781	2238.858	2226.386	1285.842	3199.352	2225.288	2233.382
1525.1	2393.335	1927.988	2282.888	2226.388	2233.385	1981.499	2225.886	2285.514
1535.1	2293.335	1916.567	8238.858	2288.386	2233.385	2241.388	3225.888	2333.388
1545.1	2293.335	1923.683	1295.484	2226.386	2138.894	2241.388	2225.886	2233.382
1555.1	2293.335	1948.943	2138.753	2338.358	2233.385	2241.388	2225.886	2233.382
[illegible]	2293.335	1981.153	2238.858	2224.188	2233.385	2177.529	3225.888	2233.383
1575.1	2293.335	1994.248	2237.458	2226.386	2233.385	1611.494	2225.886	2233.382
1585.1	2293.335	2213.858	1853.581	2228.388	2233.385	943.815	2225.886	2233.382
1595.1	2293.335	2938.648	2078.587	2228.386	2233.385	1292.791	2224.354	2233.322
1685.1	2293.335	2292.438	2858.425	1913.888	2233.385	2148.271	2224.521	2233.382
1615.1	2293.335	2878.444	2882.483	1141.872	2232.838	2238.348	2225.886	2333.382
1625.1	2293.335	2891.483	2215.958	1437.488	2233.385	2241.328	2225.228	2233.328
1635.1	2293.335	2116.485	1751.186	1767.428	2233.385	2241.388	2225.886	2238.382
1645.1	2173.883	2144.887	1581.449	1778.788	2135.874	2241.382	3225.228	2233.322
1655.1	2031.398	2177.317	1672.522	1928.275	2233.385	2241.388	2225.886	2233.382
1665.1	2398.927	2218.311	2232.121	2028.532	2233.328	2241.822	2225.882	2233.382
1675.1	1765.774	2233.712	2282.758	2147.648	2233.385	2241.388	2225.886	2233.382
1685.1	1859.429	3237.238	2825.358	2212.221	2833.385	2241.882	2225.828	2233.388
1695.1	2163.346	2237.256	2238.858	2897.145	2233.385	2241.388	2225.886	2233.382
1705.1	2189.945	2237.258	2238.858	2181.525	2233.385	2241.388	2225.288	2233.388
1715.1	2267.838	2237.256	2238.858	3213.941	2833.385	2241.388	2225.886	2233.382
1725.1	2251.224	2237.858	2238.858	2228.382	2233.385	2241.388	2225.888	2233.388
1735.1	1834.877	2237.256	2213.935	2826.388	2233.385	2241.388	2225.886	2233.382
1745.1	1613.443	2237.258	2238.858	2186.587	2233.38[illegible]	2241.388	2225.886	2233.382
1755.1	1994.883	2237.256	2238.858	1938.822	2233.385	2241.388	2225.886	2233.382
1765.1	2249.477	2237.258	2288.288	1251.343	2233.885	2241.328	2225.828	2233.322
1775.1	2238.738	2237.256	2238.858	1883.381	2233.388	2178.753	2225.886	2233.382
1785.1	2218.772	2237.256	2238.852	1458.138	2233.328	2123.131	2225.882	2233.382
1795.1	2293.335	2237.256	2238.858	1748.881	2233.385	2118.748	2225.886	2233.382
1885.1	2249.352	2237.258	2238.858	1478.883	2233.328	2881.927	2225.288	2233.388
1815.1	2242.945	2237.256	2238.858	1881.878	2233.385	2178.382	2225.886	2233.382
1825.1	1822.355	2237.258	2232.858	1743.718	2233.328	2057.182	2225.828	2233.328
1835.1	1995.498	2237.256	2238.858	1894.844	2233.385	2138.488	2225.886	2233.382
1845.1	1528.758	2237.256	2238.858	2884.478	2233.385	2174.121	2225.886	2233.382
1855.1	1891.971	2237.258	2238.858	2891.487	2233.385	2211.188	2225.888	2233.382
1845.1	1989.852	2337.256	2232.258	1718.964	2233.328	2448.918	2225.886	2233.382

Table A-VII

Temperature Data Print-Out for Round 4959

Thermocouple No.	1	2	3	4	5	6	7	8
Multiplexer Channel	01	02	03	04	05	06	09	10
Time (msec)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)	Temp. (°F)
735.1	76.488	76.954	76.707	76.806	-212.322	76.693	76.934	76.731
745.1	76.579	76.739	76.872	76.916	409.904	76.803	76.880	76.840
755.1	76.634	76.900	76.927	76.806	-876.273	76.748	76.770	76.511
765.1	76.634	76.730	76.927	76.679	613.576	76.803	76.989	76.950
775.1	76.634	76.790	76.982	76.806	-500.569	76.858	76.770	76.566
785.1	76.466	76.790	76.762	76.752	-187.030	76.693	76.880	76.676
795.1	76.589	76.790	76.872	76.806	415.434	76.803	76.825	76.731
805.1	76.524	77.864	76.927	76.916	-859.948	76.776	76.825	76.621
815.1	76.579	76.845	76.982	76.861	626.254	76.748	76.934	76.840
825.1	76.689	76.81	76.927	76.861	-487.846	76.913	76.770	76.566
835.1	76.579	76.790	76.927	76.667	-190.191	76.803	76.880	76.621
845.1	76.745	76.625	76.872	76.806	421.432	76.913	76.825	76.731
855.1	76.639	77.889	76.927	76.806	-867.241	76.748	76.934	76.676
865.1	76.634	76.735	76.927	76.806	611.939	76.903	76.825	76.895
875.1	76.689	76.845	76.982	76.752	-508.900	76.858	76.825	76.511
885.1	76.468	76.900	76.872	76.752	-208.465	76.803	76.825	76.758
895.1	76.579	76.790	76.927	76.697	417.287	76.913	76.989	76.621
905.1	76.689	76.954	76.927	76.861	-877.224	76.858	76.880	76.566
915.1	76.689	76.680	76.817	76.916	613.070	76.693	76.934	76.676
625.1	76.634	76.845	76.927	76.861	-513.613	76.913	76.880	76.566
935.1	76.358	76.790	76.817	76.806	-203.212	76.693	76.825	76.676
645.1	76.669	76.790	76.817	76.806	408.574	76.803	76.934	76.731
955.1	76.579	77.889	76.927	76.970	-863.905	76.693	76.825	76.621
665.1	76.524	76.845	76.872	76.861	623.352	76.693	76.689	76.950
975.1	76.689	76.790	76.927	76.806	-510.277	76.968	76.934	76.511
985.1	76.524	76.660	76.762	76.806	-193.231	76.693	76.770	76.621
995.1	76.634	76.845	76.927	76.861	405.017	76.913	76.880	76.785
1005.1	76.934	76.790	76.927	76.806	-869.598	76.913	76.934	76.621
Ignition 1015.1	76.468	76.570	76.817	76.667	622.804	76.748	76.880	76.785
1025.1	76.800	76.845	76.927	76.724	-532.563	76.803	76.770	76.456
1035.1	84.529	84.278	84.878	76.642	47.092	76.473	76.825	76.568
1045.1	122.959	127.222	116.578	77.462	145.217	77.048	77.153	76.785
1055.1	176.730	191.482	178.384	82.805	30.903	84.883	77.868	77.005
1065.1	252.686	286.200	232.155	63.662	48.473	96.144	78.308	76.785
1075.1	344.426	410.849	318.954	111.497	148.357	121.618	81.884	77.169
1085.1	407.165	508.614	382.170	136.248	113.724	150.285	84.936	77.608
1095.1	485.179	578.987	427.345	167.298	234.948	183.189	93.958	79.292
1105.1	521.738	647.204	461.860	186.685	243.261	221.150	105.180	82.845
1115.1	567.241	701.951	498.844	233.815	243.567	259.783	118.180	86.591
1125.1	611.329	758.483	538.884	264.758	315.146	292.363	132.958	90.667
1135.1	655.503	805.845	585.385	295.126	292.177	324.488	148.722	97.698
1145.1	716.632	882.176	648.663	324.481	374.112	356.478	166.214	105.112
1155.1	795.858	959.865	703.558	353.159	403.531	391.488	184.564	113.886
1165.1	874.188	1020.884	758.226	387.224	386.867	432.861	203.441	123.260
1175.1	922.585	1071.982	798.329	421.202	456.334	480.874	224.812	133.454
1185.1	973.472	1123.884	847.448	458.639	478.419	525.877	249.281	144.289
1195.1	1025.488	1170.157	888.650	648.621	531.054	566.683	267.291	156.142
1205.1	1074.664	1218.662	947.177	928.249	591.247	605.613	286.829	168.826

1215.1	1118.826	1260.765	991.276	959.722	569.936	642.842	312.519	182.612
1225.1	1158.532	1343.872	1020.424	594.544	852.231	676.859	335.285	196.471
1235.1	1197.368	1387.996	1067.523	629.271	632.783	710.762	358.387	211.15
1245.1	1237.439	1431.282	1106.613	662.428	725.758	741.593	381.979	226.332
1255.1	1273.821	1467.112	1144.426	697.422	716.279	771.835	405.436	241.526
1265.1	1307.320	1499.809	1181.417	731.900	723.248	803.567	429.382	257.630
1275.1	1339.426	1533.868	1217.845	764.560	797.107	834.972	453.041	273.014
1285.1	1369.689	1566.953	1255.292	797.353	783.437	866.993	476.113	288.777
1295.1	1396.481	1598.214	1301.114	829.776	881.663	899.307	498.859	305.184
1305.1	1422.195	1760.929	1691.971	861.295	874.123	930.384	520.367	321.653
1315.1	1444.937	1830.534	2936.201	891.430	936.710	1297.899	541.970	347.764
1325.1	1468.777	1857.393	1889.663	920.045	1189.679	1369.868	564.327	421.816
1335.1	1496.962	1881.562	2238.504	949.020	1037.600	1439.327	567.939	538.082
1345.1	1566.150	1791.969	2173.545	997.603	1255.207	1444.633	612.797	781.072
1355.1	1626.159	1607.311	2168.942	1260.284	1326.700	1477.469	642.157	2194.268
1365.1	1682.054	2036.650	1229.418	1363.412	1363.609	2014.928	680.532	2137.341
1375.1	1759.488	2232.049	2238.504	1368.506	1655.534	2241.196	809.232	2210.355
1385.1	1605.409	2205.894	2238.504	1713.930	1583.290	2099.756	872.378	1940.904
1395.1	2018.316	1929.242	2238.504	1966.795	1880.205	2241.196	921.321	2015.971
1405.1	2079.116	2230.936	1683.092	2199.291	1679.308	2241.196	1097.528	2195.469
1415.1	2080.384	2237.761	2238.504	2049.891	2032.191	2201.044	1903.146	1484.984
1425.1	2036.091	2176.243	2238.504	2220.416	2233.274	2193.201	2225.806	2136.694
1435.1	1401.074	2093.757	2238.504	2226.416	2233.274	2241.196	2225.806	2233.753
1445.1	1931.242	2194.897	2238.504	2226.416	2233.274	1826.449	2225.806	2233.753
1455.1	2233.972	2179.880	2238.504	2228.416	2233.274	1720.067	2225.806	2233.753
1465.1	2189.847	2230.578	2196.411	2226.416	2233.274	1873.661	2225.806	2233.753
1475.1	2252.403	2205.803	2221.445	2226.416	2233.274	1894.602	2225.806	2233.753
1485.1	2252.653	2223.796	2223.022	2226.416	2233.274	2241.190	2225.806	2233.753
1495.1	1889.474	2186.242	2238.504	2226.416	2233.274	2241.196	2225.800	2233.753
1505.1	1226.751	2237.761	2238.504	2226.416	2233.274	2241.196	2225.806	2233.753
1515.1	2253.448	2237.761	2238.504	2226.416	2233.274	2241.196	2158.573	2233.753
1525.1	2253.448	2237.761	2238.504	2226.416	2233.274	1069.533	1881.902	2233.753
1535.1	2253.448	2237.761	2063.974	2220.416	2233.274	89.728	1834.620	2233.753
1545.1	2253.448	2237.761	2238.504	2226.416	2233.274	-232.403	1848.916	2233.753
1555.1	2253.448	2237.761	2238.504	2225.690	2233.274	-19.474	1813.524	2233.753
1565.1	2253.448	2237.761	2238.504	2217.543	2233.274	-213.576	1809.343	2233.753
1575.1	2253.448	2237.761	2238.504	2188.592	2233.274	-32.542	1821.914	2233.753
1585.1	2253.448	2237.761	2238.504	2104.145	2233.274	282.805	1822.225	2233.753
1595.1	2253.448	2237.761	2238.504	2148.389	2233.274	2241.198	1827.794	2233.753
1605.1	2253.448	2237.761	2238.504	2121.485	2233.274	2217.102	1835.956	2233.753
1615.1	2253.448	2237.761	2238.504	2107.345	2233.274	2241.196	1832.659	2233.753
1625.1	2253.448	2237.761	2238.504	2105.718	2233.274	2241.196	1831.933	2233.753
1635.1	2253.448	2237.761	2238.504	2080.417	2233.274	2241.196	1835.869	2233.753
1645.1	2253.448	2237.761	2238.504	2058.436	2233.274	2241.196	1840.405	2233.753
1655.1	2253.448	2237.761	2238.504	3025.593	2233.274	2241.196	1835.138	2233.753
1665.1	2253.448	2237.761	2238.504	2015.328	2233.274	2241.196	1826.884	2233.753
1675.1	2253.448	2237.761	2238.504	2022.813	2233.274	2241.196	1840.414	2233.753
1685.1	2253.448	2237.761	2238.504	2017.816	2233.274	2241.196	1853.354	2233.753
1695.1	2253.448	2237.761	2238.504	1929.164	2233.274	2241.196	1859.159	2233.753
1705.1	2253.448	2237.761	2238.504	2884.587	2233.274	2241.196	1852.997	2220.878
1715.1	2253.448	2237.761	2238.504	2143.274	2233.274	2241.196	1854.766	2001.602
1725.1	2253.448	2238.406	2238.504	2125.981	2233.274	2241.196	1847.138	1998.995
1735.1	2253.448	2212.206	2238.504	1874.571	2222.329	2241.196	1833.107	2164.218
1745.1	2253.448	2205.708	2238.504	1473.497	2233.274	2241.196	1814.793	2231.511
1755.1	2253.448	2233.715	2238.504	1185.488	2183.820	2241.196	1791.918	2233.753
1765.1	2252.884	2229.456	2238.504	1248.488	2183.382	2241.196	1771.758	2233.753
1775.1	2207.774	2186.091	2238.504	1459.948	2233.274	2241.186	1795.883	2233.753
1785.1	2109.429	2047.523	2238.504	1957.784	2238.362	2241.196	1736.314	2233.753
1795.1	2043.817	2038.457	2238.504	1988.148	2226.822	2241.196	1719.370	2233.753
1805.1	1915.538	2048.148	2238.504	1811.478	2233.274	2241.196	1702.176	2233.753
1815.1	1785.102	1964.626	2238.504	1814.898	2233.274	2241.196	1682.102	2233.753
1825.1	1749.588	1976.538	2238.504	1637.817	2233.274	2241.198	1667.832	2233.753
1835.1	1721.398	1846.857	2232.304	1784.813	2233.274	2241.196	1652.572	2233.753
1845.1	1717.189	2891.269	2238.504	1828.421	2233.274	2241.196	1625.870	2233.753
1855.1	1624.673	1883.879	2238.504	2037.129	2233.274	2241.196	1618.491	2233.753
1865.1	1746.799	1186.768	2238.504	1946.126	2238.274	2241.196	1601.884	2233.753

APPENDIX B

TABLE OF NOMENCLATURE

A_e = Nozzle exit area

K = Ratio, burning surface area to nozzle throat area

$\dot{m}$ = Propellant mass divided by the action time

$\overline{P}_a$ = Average pressure over the action time

$\overline{P}_b$ = Average pressure over the burning time

$\overline{r}_b$ = Average burning rate over web burning time

t_a = Action burning time

t_b = Web burning time

η = Ratio of corrected measured specific impulse to theoretical specific impulse at 400 or 550 psia (whichever is appropriate)